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The Meade Accessory Package, shown with standard-equipment SP 26mm eyepiece.

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*This offer is valid only for telescopes purchased **between September 1, 1991, and November 30, 1991** and delivered in the USA and Canada. Registration Cards and invoice copies sent to Meade Instruments must be postmarked not later than December 15, 1991.*

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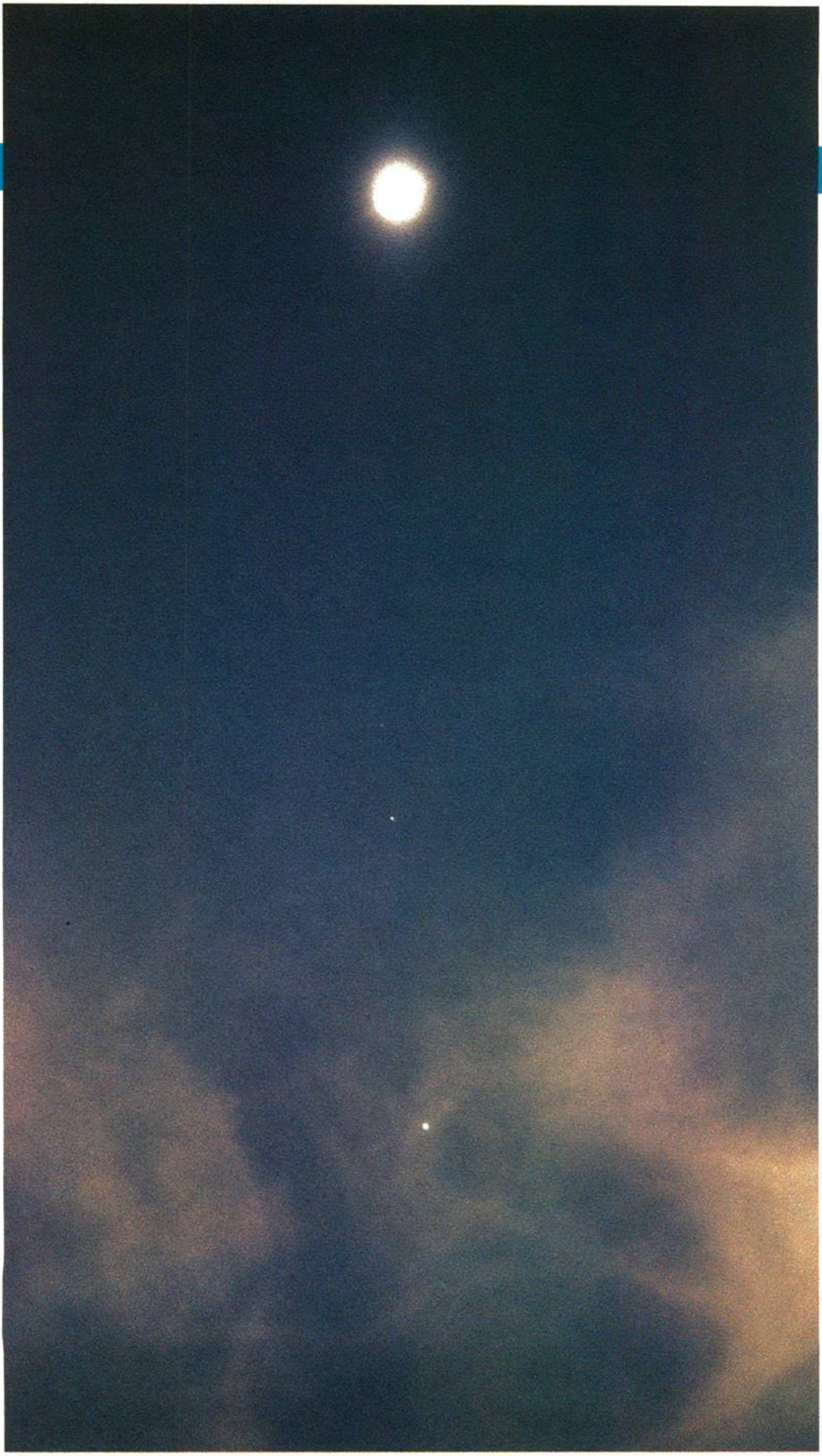
**ON THE COVER:** Long-awaited and much anticipated — the July 11 total eclipse of the Sun was everything eclipse watchers had hoped it would be. A first report on the spectacular eclipse starts on page 64. Photo by Ernie Piini using a special f/6.8 telescope built for eclipse photography, a radial gradient filter, Ektar 125 film, and a 2-second exposure. Photo taken from San José del Cabo, Baja California.



**DURING TOTALITY** *on July* 11, Richard Horwitz captured the eclipsed Sun, Mercury (nearest the Sun), Jupiter, and Venus in the midday darkness. Photo taken from the cruise ship *Viking Serenade,* in the Sea of Cortez.

# ASTRONOMY®

**October 1991**

**Vol. 19, No. 10**

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From the Big Bang to the fate of Earth, a dramatic collection of imaginative images from one of the world's leading space artists takes you on a journey through time and space. Paintings by Adolf Schaller, story by Robert Burnham.

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The biggest and brightest planetary nebula in the sky is a challenge to find but a delight to see. By David Higgins.

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The
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## Behind the Scenes

# ENVISIONING THE UNIVERSE

Art captures the imagination as no photograph can. To embrace the vastness of the universe or reach into the depths of time requires the act of creation, and behind creation lie understanding, reflection, and the synthesis of ideas. Creation occurs as the artist's mind guides paint from a brush, graphite from a pencil, or the spray of color from an airbrush to paper, cardboard, or canvas.

This month we are pleased to welcome back an old friend, artist Adolf Schaller. Thoughout ASTRONOMY's early years, Adolf's work frequently graced our pages. In 1974, he painted Mars as the Viking landers would see it. In 1976, he created the first vivid and accurate images of the terrible "central engines" of galaxies and quasars. In 1978, Adolf showed ASTRONOMY's readers the high clouds of Jupiter much as Voyager would later reveal them. Imagination preceded reality and we shared his sharply focused vision of the universe.

This month Adolf shares a larger vision than ever before. Now a veteran of Carl Sagan's *Cosmos,* a series of motion pictures, and the recent PBS miniseries, *The Astronomers,* Adolf has painted a portrait of the history of the cosmos for us to share. His paintings and our accompanying story begin on page 30.

Yet even as we admire the artistic act of imagination, there is much to be said for the flat facts of reality recorded by photography. No other medium can sample and hold the precise pattern of light streaming toward us from a celestial event. As Alan, Dave, Rich, and I watched those final moments before the Moon's disk completely blocked the solar photosphere, too much happened too quickly. In a few split seconds the Sun's disk disappeared, the spiculed chromosphere popped into view, and the corona spread wide and white against a blue-black sky.

Motor drives whirred and shutters opened; light fell on film and trapped electrons within minute crystals of the halide salts of silver. As the shutters snapped shut, those crystals retained a precise record of where light had fallen on the film, and the eclipse was recorded for you to see in these pages. Our record of ASTRONOMY's eclipse begins on page 64.

Much as the artist does, the photographer uses the imagination and prepares for the moment, envisions the scenes, points the camera, and in a split second captures a vision for others to share. Much as the photographer does, the artist studies light and yearns to reproduce its effects so as to capture a vision for others to share. They are complementary and we need them both.

Sincerely,

Richard Berry

Richard Berry

ASTRONOMY

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## Letters

### Jupiter in Stereo

The remarkable series of photographs of Jupiter and Io on pages 90 and 91 of the June 1991 issue is revealing in a manner perhaps not expected by the authors. Any pair provides a 3-dimensional view through stereopsis. Jupiter will appear as a sphere projecting from the page and Io will appear suspended above Jupiter.

The most convenient method of visualizing this is to hold the page squarely at arm's length. Cross your eyes slightly (as though an imaginary object between your eye and the page were being studied) so that the two images appear to merge into one. Minor adjustments in the tilt of the page and eye focus may be necessary. It may require some effort and practice, but is it rewarding!

The stereo effect arises from the subtle differences in perspective produced by the rotation of the planet between frames. Io's shadow does not appear to be at cloud top, but above it. This may result from the orbital motion of Io between frames.

Saturn would be an interesting subject for this kind of study. To obtain images suitable for seeing the rings in 3-D, you will need long time intervals between frames. — *O. A. Mamer, Montreal, Quebec, Canada*

### Energy from the Big Bang

The Big Bang states that the universe was created about 15 to 20 billion years ago. Yet the laws of conservation state that the total amount of energy and matter in the universe can never change. Matter and energy can neither be created nor destroyed, merely changed from one form into another.

Based on this law, the universe, which is essentially energy, could not have been created 15 to 20 billion years ago as proposed by the Big Bang theory. Furthermore, other theories regarding the universe which imply that the universe was created or that the universe will end appear in total violation of this law.

Can you clear up this apparent contradiction? — *Scott R. Williams, Waterloo, Iowa*

*— Interestingly, the total energy of the universe is believed to be zero. As the universe expands outward in the early stages of the Big Bang, positive energy (light energy and energy of motion) increases. Some of this positive energy is transformed into matter. The positive energy increase is balanced by the increase in gravitational interaction between*

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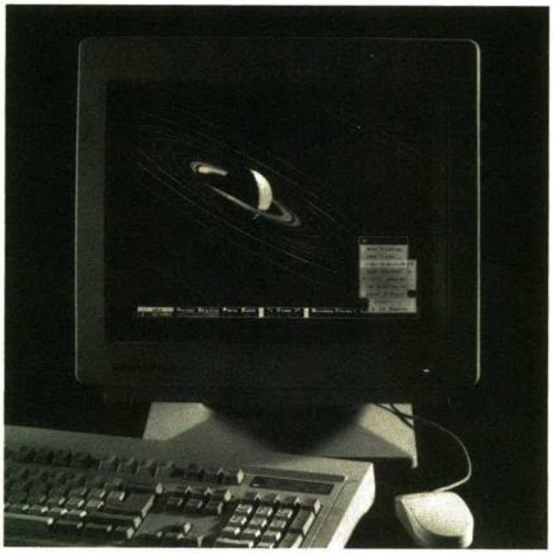

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It's the perfect synthesis of rich-field and long focus refractors, spotting scope and fast telephoto lens in one stunning instrument weighing just 10 lbs.

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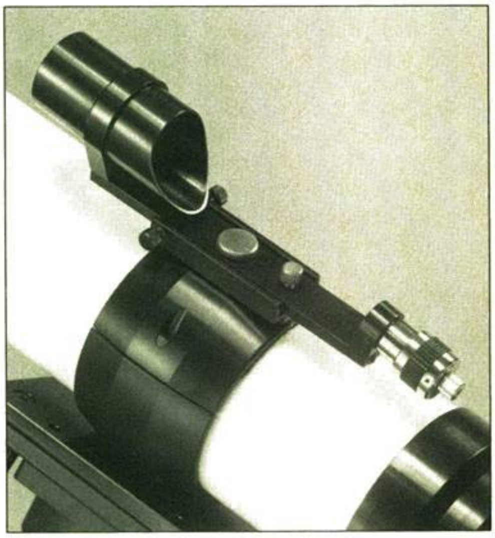

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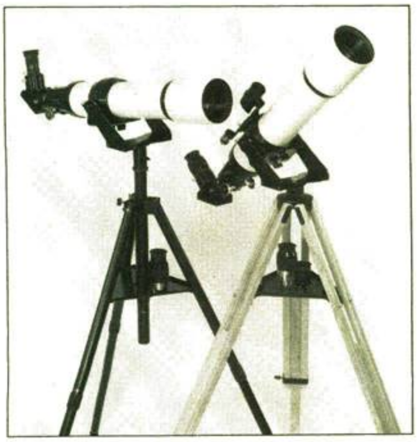
The Panoramic Mount is available with your choice of either an aluminum or wood tripod. The lightweight aluminum tripod has the same great features of the tripod used in the Tele-Pod. The wood tripod is beautifully crafted from American ash for added vibration damping. Both tripods include a convenient accessory tray.



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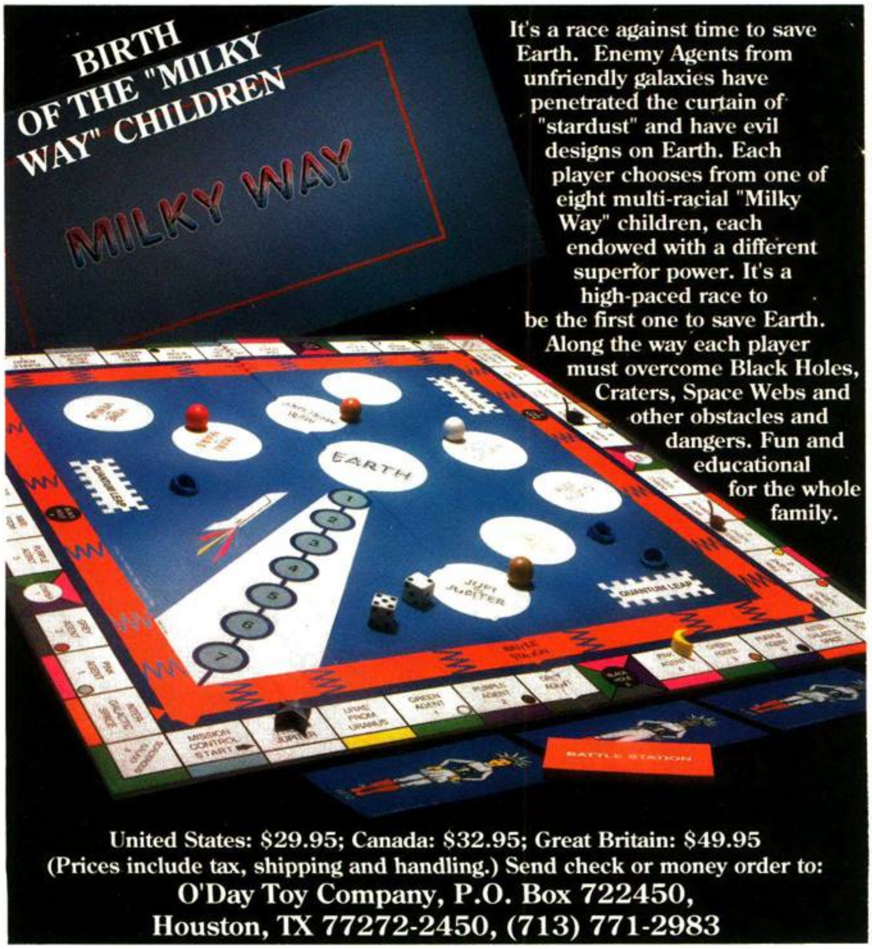

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*pieces of matter (negative energy) so the total energy remains zero. This energy balance also appears to explain why the universe expands at near the critical rate — the rate that determines whether the universe will continue to expand forever or eventually contract. Stephen Hawking's* A Brief History of Time *describes this energy balance in more detail.*

**Astronomy on a Budget**

I was inspired by Reader Reports in the July 1991 issue. As an amateur astrophotographer and astronomer, I find it difficult to locate equipment I need at reasonable prices. Recently, I went to a camera shop to look for a camera to take some pictures of the Moon and the planets. The manager just looked at me and said, "You shouldn't waste your money. There are hundreds of photographs already taken of the Moon and planets." I realized he wasn't much of a salesman.

I agree with Mike Lynch. I'm through admiring other people's photographs. I'm going to take my own! — *Carla J. T. Reeves, Pleasantville, New Jersey*

Cindy Cline's letter (June 1991 issue) about spoiled, whining scope owners was totally unfair. I have owned a 3-inch telescope for years and have been saving for an "upgrade." I'm very thankful for the scope I have, and certainly wouldn't say anything bad about it or Ms. Cline's binoculars. I simply want to see more; if that's spoiled and whining, so be it. It's not a matter of "picking up aluminum cans," which I do. The fact is, many telescopes are beyond the financial reach of many of us.

Deborah Isaacson's letter (June 1991 issue) hit home. I also used to sneak out to stargaze until I hit on a marvelous idea: After putting my two-year-old to bed, my four- and five-year-old sneak out with me. They choose the "target" and then I explain, in age-appropriate language, what they are seeing. If I don't know, we make a big point of looking it up in the sky chart. After an hour, they go to bed full of awe and hungry for more. And I have hours left to myself. We've grown to cherish the extra time together. — *Tommi White, Emmett, Idaho*

I tend to be a perfectionist when it comes to the tools I use in any field of endeavor. So I have undergone a fair degree of anxiety in seeking and selecting relatively inexpensive telescopic equipment, only to read a lot about the inherent optical deficiencies and poor craftsmanship of such equipment. But I think it's very important that non-rich amateur astronomers (at least) keep things in perspective. Our binoculars and telescopes are our eyes and windows to the heavens. What does it matter if they don't give us perfect vision? We would hardly see anything at all without them.

I own a pair of 7x50 binoculars, a spotting scope, and a 10-inch Dobsonian reflector. The views I get from them are astonishing. I soon forget to worry about spherical aberration, chromatic aberration, astigmatism or coma. The key for me is avoiding high power.

Professional astronomers need highly sophisticated equipment. But for the amateur who just wants to appreciate firsthand the serene and awesome natural beauty of the universe, the simple way can indeed be more than adequate. — *Ted Aranda, Chicago, Illinois*

**Earth Tides with No Moon**

Neil Comins states in his article "The Earth Without the Moon" (February 1991 issue) that the length of a cycle from high tide to low tide and back to high tide would be twelve hours and four minutes, or about half a solar day. The extra four minutes is due to the Earth's motion around the Sun.

I expected that a tidal cycle driven only by the Sun would take exactly half a solar day. I do not understand how the additional four minutes in the author's solar tide cycle arise. — *Edward J. Mulcaster, Essex, Ontario, Canada*

*— When discussing the orbital motions of the planets, it is common to measure time in terms of the Earth's rotation with respect to the stars rather than the Sun. The stellar-based, or sidereal, tidal period was reported by Mr. Comins in his article. If solar time were used, the tidal period would be exactly 1/2 day.*

If the Moon slows the Earth's rotation by 0.002 seconds per century, then Earth's rotational period one billion years ago should have been 18.4 hours rather than the 21 hours stated by Mr. Comins. Following this logic, 4.65 billion years ago the Earth's rotational period should have been -1.8 hours. Obviously, this rate has not been constant. — *B. Gray and R. Acosta, El Paso, Texas*

*— The slowing of Earth's rotation rate is closer to 0.0015 seconds per century, but it was rounded up for the article. However, it is dangerous to extrapolate this rate of slowing to longer times owing to the inconstant tidal forces between the Earth and Moon. Estimates of the Earth's rotation period when the Moon was closest to the Earth billions of years ago are about 4 to 5 hours.*

Mike Flegal maintains in his letter (May 1991 issue) that the Earth and Moon will never have the same period of rotation. Mr. Comins states correctly, however, that someday they will have the same period. Energy is not constant as claimed by Mr. Flegal; tidal friction on Earth constantly dissipates energy. Earth and the Moon will have similar rotational periods in about 50 billion years when the day and month will be 47 present solar days long. — *John M. Hanson, Huntsville, Alabama*

**Brrr! It Was COLD!**

I remember the cold winter winds of Montana during the February 26, 1979 total solar eclipse. We flew to Missoula and begged a ride with a local reporter to the ski resort. Carrying a camera bag and tripod, I rode a ski lift for the first and only time in my life. During the time of the eclipse, a snow squall moved across the face of the mountain. It would have been dark even without the eclipse.

This was my third and last attempt to see a total eclipse. I've never seen more than a partial eclipse, but the effort has still been worth it. I look forward to the pictures of those more successful. — *J. L. Abbott, Mesquite, Texas*

**Request for Star Charts**

The Sokolniki Park Amateur Astronomical Group (Moscow) has requested the donation of *Sky Atlas 2000.0* and *Uranometria 2000.0*. Good sky charts are not published in the Soviet Union, and they would like some help in providing these charts to the over 100,000 people who visit their observatory annually.

If you are interested in donating some charts to this group, please contact Terry Fabian or Sherman Schultz at the Planetarium, Macalester College, 1600 Grand Avenue, Saint Paul, MN 55105. Phone (612) 696-6383. ☐

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*ASTRONOMY welcomes comments, suggestions, and additional information on articles and astronomy in general. Send your letters to: ASTRONOMY Letters, P.O. Box 1612, Waukesha, WI 53187. Letters may be edited for length or clarity.*

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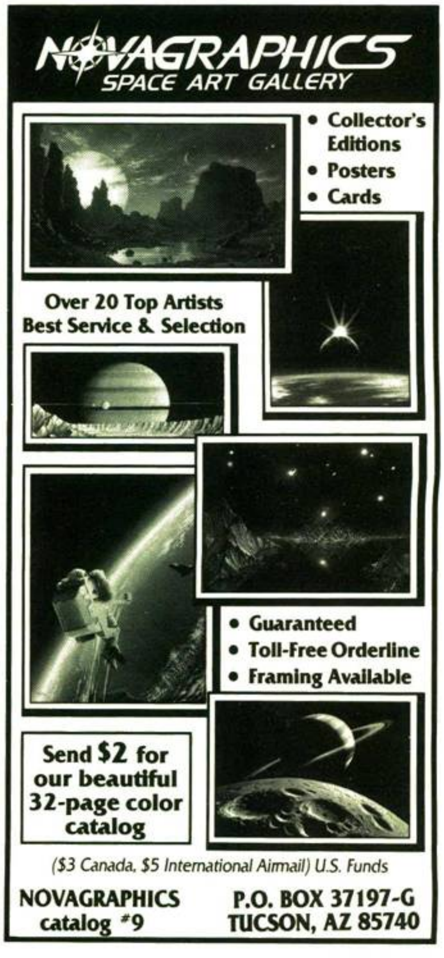

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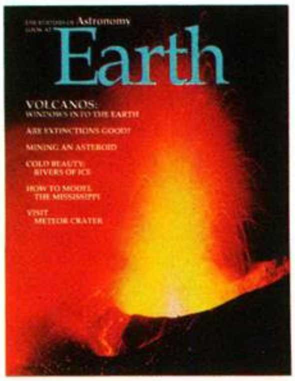
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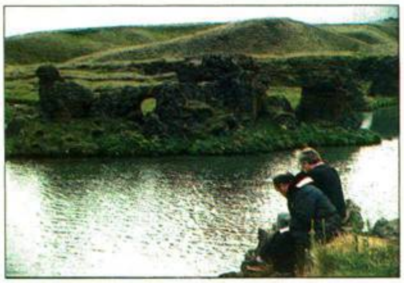

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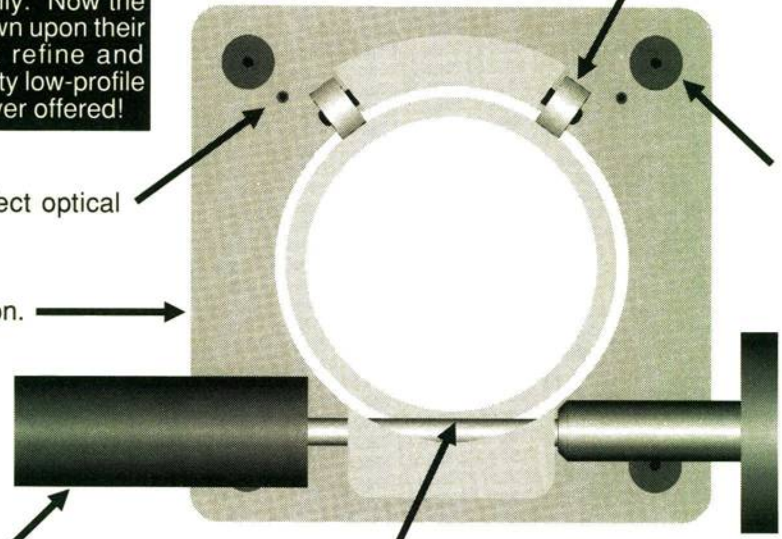
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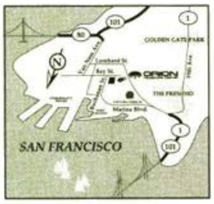

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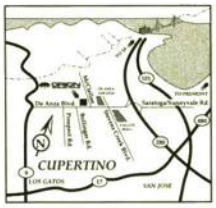

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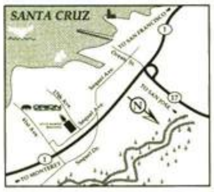

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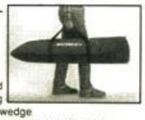

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# SHEPHERDING THE STARS

by Susan C. Cook

Astronomy began for me back in 1980, thanks to twin baby lambs. At the time, I was employed as a secretary for a small architectural firm, and one of the architects raised Rambouillet sheep as a hobby. One clear, crisp, starry January night as he was out in the meadows near the lambing pens waiting to help with a few imminent lamb deliveries, he looked up to a velvety heaven filled with bright lights.

So taken was he by this first real look at the sky — and especially by two brilliant objects (one red and one white) — that the next day he asked if anyone knew what these two "stars" could be. Since no one did, he asked if I would call our museum to find out. I called, and the following night when the twin lambs were born, he christened them Mars and Jupiter.

My curiosity was piqued. So I stepped out the next clear night, took a look, and found those two magnificent objects. And was immediately bitten by astronomy myself. From then on, as I went on my accustomed nightly constitutionals, I found my eyes drifting up to scan the skies. It wasn't long before I became frustrated, wanting to know what those beautiful configurations of stars were called — especially that one with three stars in a row surrounded by a rectangle of four bright ones.

Sometime later, I discovered that a local wildlife sanctuary held an occasional star program. This opened the door to the heavens, which I have since pursued through membership in a short-lived astronomy club. (The club lasted long enough for members to teach me that the three-star affair is part of Orion.)

My very first purchase was the little Golden Guide book *Stars*, which I read and reread a hundred times before I could master the difference between a galaxy and the solar system, celestial motions, and the fact that the same side of the Moon always faces us. Eventually, I added Guy Ottewell's *Sky Calendar*, Ian Ridpath's *The Night Sky*, and a self-teaching guide. Yet learning astronomy hasn't come easy. Using these materials, however, I would make my lists of things to look for, scoop up my binoculars, and skip out to our limited-horizon backyard — or head off around the corner to a not-too-dark school field. Ever so slowly I began to learn the seasonal constellations and major stars within them.

Attendance at other sanctuary star programs took me further. So clear is my memory of the first time the leader guided me to the stars which led to the exhilarating smudge of M31, my very first galaxy. And the absolute joy of seeing the crown jewel Saturn in a 6-inch homemade telescope. Very heady stuff. I learned what "M" objects were and began to pursue nebulae and clusters, feeling so smart to have done so on my own.

Another unforgettably vivid image came on the night I saw a phenomenal fireball. This happened during a program as we were about to close up shop around 10 p.m. with only three of us left. We were facing east, discussing a most complex issue for me — right ascension and declination. (In my earlier days, I thought "Dec" meant the month when certain constellations were visible!)

Then the world around us lit up as though slow lightning had struck. Within seconds, a gold and green fireball zoomed overhead, coming from the west, and was gone. I don't think anyone breathed for five minutes. When we again found our voices, we

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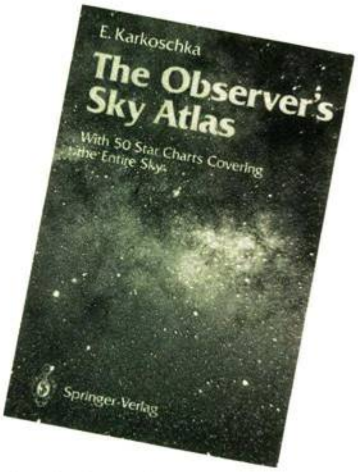

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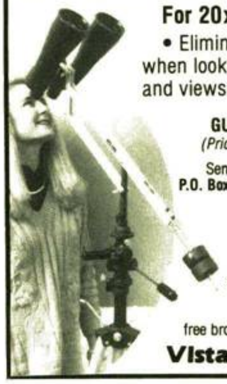

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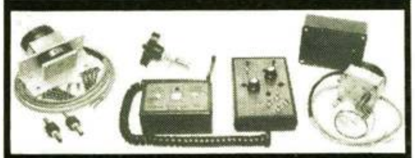

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agreed this would go down in our books as a once-in-a-lifetime incredible sight.

Ironically, I'm not a night person nor do I enjoy the real heat of summer or the bugs that accompany it. So most of my stargazing is done in the fall, winter, and spring whenever I can muster the push to get on the heavy clothes and get out there where I struggle to keep my eyelids up. But all it takes is a look at Jupiter's moons, the Beehive star cluster, or the Lagoon and Trifid nebulae, and I go all dreamy.

My library still consists of only the above-mentioned books and my equipment remains the same 7x50 binoculars I began with. That's not to say I don't devour all the telescope ads. However, I find the portability and simplicity of binoculars, for now anyway, outweigh the complexities of more advanced aids to viewing.

Astronomy has truly opened my eyes and my world. My only regret is that I didn't look up years ago. And when I stand under an exquisitely starry sky, I think about long-ago shepherds and sheep and say an extra special hello to the red one and the white one when they are visible.

## *A RADICAL ASTRONOMY?*

by Harriet Witt Miller

Can we use astronomy as a tool for social change?

I think we can and should, but maybe a little background on some astronomy teaching I do will help you understand why I'm asking.

My astronomy students are always waiting on three plush maroon couches next to a large mounted elephant tusk on the second floor of the hotel. I introduce myself to them, check off their names on my list, and explain that we'll be using a 16-inch telescope, the most user-friendly public scope in the world. I tell them we'll also be seeing why the sky is the original clock, calendar, compass, and time machine.

Then my ten students and I board the elevators, ride up to the ninth floor, and get off. Single file, we snake our way through a series of locked doors, halls, and stairways until we open one last door onto the hotel roof. The star-studded night caresses us with its salty-sweet tropical air. We snake across the roof on a narrow steel grid walkway, aiming for the little red lights that surround our observing platform on the southern rim of the roof, overlooking the Pacific.

Sharing astronomy with the upscale guests of the Hyatt Regency Maui is a long way from sharing it with Atlanta-area school kids at an environmental education center in the Southern Appalachian mountains. The Georgia pupils have been released from school for several days in the country, while my Hawaii pupils are folks on vacation in paradise. But both jobs have something in common: all of my students are in an upbeat mood, have their minds open, and are primed to expand their thinking beyond the range of their daily rat race. Since none of the students are being graded, both jobs have let me teach astronomy, not just for facts, but for its quiet, unobtrusive way of dissolving static belief-systems and replacing these with the awe and openness that encourage creative thinking.

Once the Hyatt guests take their seats on the roof, I ask (if Polaris and the Big Dipper are visible that night), "Do you all know how to find the North Star?" Even people who know zip about astronomy are aware this star is important but they generally aren't sure why and often think, mistakenly, that it's the brightest star in the sky.

I tell them the real reason for its importance, and then show them the "clock hand" between Polaris and the Pointers. After they've had about an hour to watch the sky swing around Polaris, they recognize the sky was our original clock. They realize that time isn't always what it says on our watches — in fact, time can be where we are in the sky. By upsetting everyday assumptions and making fundamental concepts such as time begin to come alive, I find that even the passive members in the group become more alert in their questions (and, I hope, their thinking).

Folks who already know the North Star notice it's lower in Hawaii than on the mainland and want to know why. I ask them to imagine traveling north and watching Polaris getting higher in the sky until it's directly overhead when they reach the pole. I ask them to imagine traveling south and watching Polaris sinking in the northern sky until it drops below the horizon when they reach the equator. As this idea plays in their minds, they begin to see how someone could navigate by the stars.

If the Southern Cross is visible I point it out to them, happy to share a treat that most of them can't enjoy from home. When they ask why they can't, I explain that northern-latitude observers can't see anything that far south of the celestial equator for the same reason

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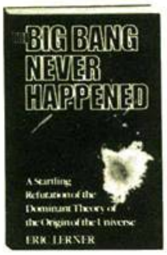
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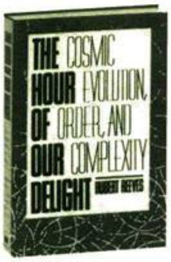
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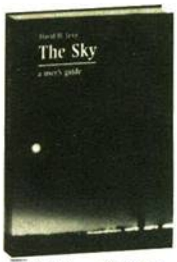
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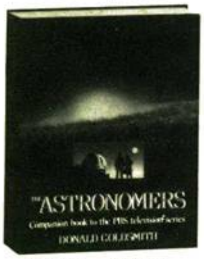
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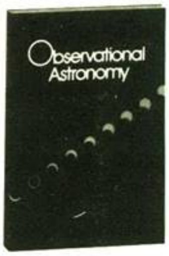
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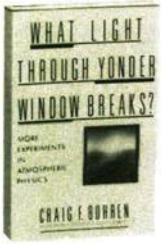
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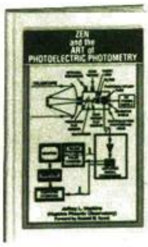
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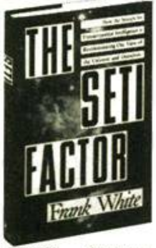
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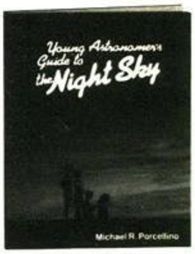
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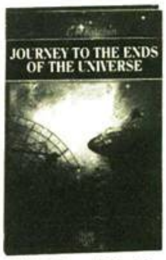
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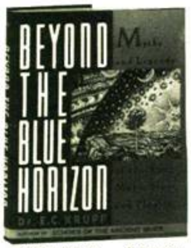
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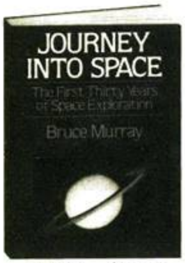
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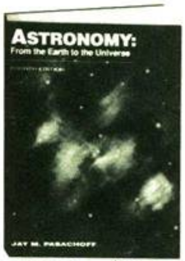
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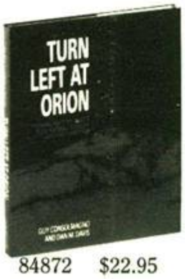
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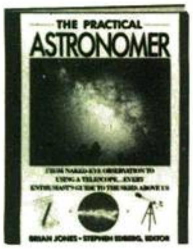
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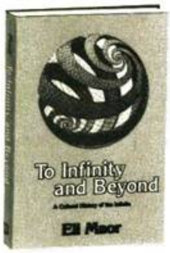
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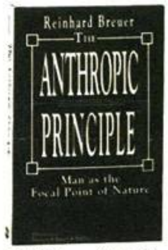
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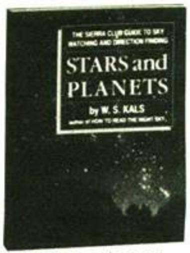
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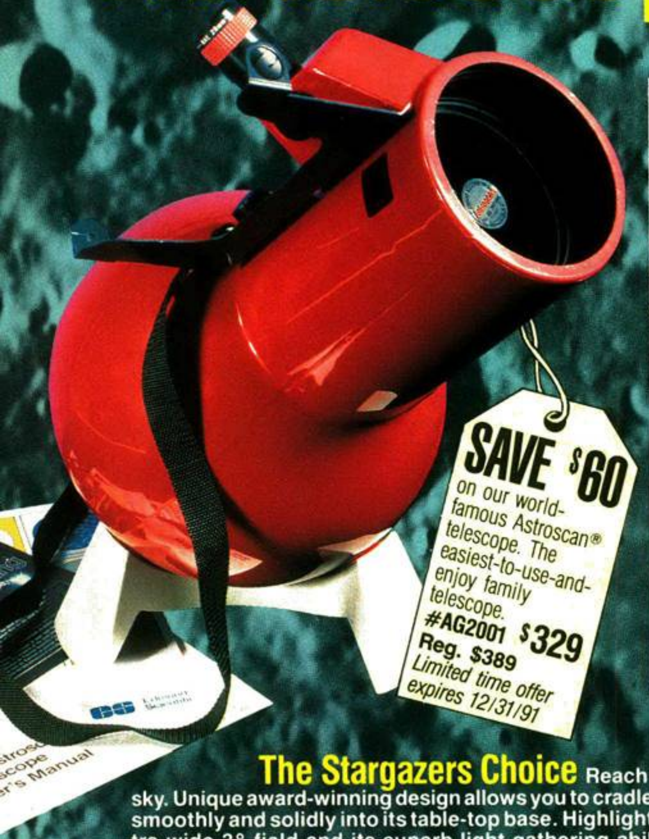

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that a fat man can't see his knees over the bulge of his belly.

As the evening wears on, I can tell by people's comments that Earth and sky are starting to feel like home. To help them locate different sky objects I draw on an idea used in many introductory astronomy classes: the ancient method of finding one's way around the sky by measuring it with our fingers. (If you've never done this — I urge you to try it! You can't imagine how much fun it is to map a few constellations using only eyes, arms, hands, fingers, pencil, and paper.)

At the Hyatt, I extend my arm to its full length and show people how such-and-such star is, say, three finger-widths from another star, or I show them how some star is as far from another as the thumb's tip is from the pinkie's tip. They often snicker at my measuring device and point out that hands and fingers often have different sizes.

"Yes," I respond, "but people with bigger hands usually have longer arms."

As they find their way around the sky, the students rediscover *Homo sapiens'* original measuring instruments. In an age when layers of technology insulate us from nature and often isolate us from ourselves, this personal relationship with the sky connects us with some of the same accomplishments that earned our species the name *sapiens* — we learned how to map the sky and use that map for exploring our planet. We also learned how to record and respect — without any tools beyond our bodies and our landmarks — the complex matrix of natural rhythms in which our species evolved.

Most people know the term light-year, but few have a mental picture of what a light-year is. Even fewer realize the implications of the fact that light takes time to travel. I point out that in looking at, say, Deneb we're witnessing something that happened about 1,500 years ago. In looking at galaxies through the telescope we're seeing millions of years into the past. Inevitably, it dawns on someone that what we're seeing now may not exist now. Another person then realizes that our today is somebody else's future. Abruptly the group finds its everyday notions about "now" and "then" dissolving.

The list of astronomical mind-expanders is a long one, and since astronomy deals with nothing less than "the big picture" — within which all other disciplines have carved out their niches — it has always been the queen of all the sciences. Astronomy is the ultimate interdiscipline.

So it makes you wonder: since no other science can zoom us through such vast differences in perspective, shouldn't we use it to liberate ourselves from that pinpoint in space-time where our bodies and egos are isolated? Can you think of a better science to catalyze the broad, interdisciplinary thinking that all of us need to tackle the monumental challenges facing our species now?

If you've ever spoken much with the general public about celestial things, you've discovered that learning astronomy can be a truly radical experience for people. The word "radical" comes from the Latin *radix*, meaning root. So a radical experience is one that shocks us out of our accustomed habits, attitudes, and cultural conditioning. It shatters those unspoken assumptions which are so ingrained that we regard them as properties of external reality. In short, a radical experience returns us to our roots.

A truly radical astronomy could play a major role on a planet where we still go about day-to-day living as if the Earth were flat. Yes, of course, Columbus showed the Earth is round but as with so many big breakthroughs, our comprehension of this has grown with geological slowness. Even our leaders still believe there is an edge — an end to reality — over which we can safely dump our toxins, store our arms, hide our debt, and stuff our responsibility to future generations. Every day we toss litter out of our cars, people out of our lives, and unfinished business out of our minds, believing that these things are over the edge of reality where they can't come back to haunt us. Astronomy can decenter our perspectives from everyday things, and reorient us to a larger reality in which there are fewer "edges" and more interconnectedness.

Radical astronomy is nothing new. It's been around for as long as good public speakers have been talking about the sky, and there seem to be growing numbers of people doing that now. The only thing new is the name. Once we have a name for it, we have a way to focus on it, brainstorm about it, and nourish it to its full potential as a tool for promoting the kind of thinking our home planet needs to survive.

I for one think astronomy has great potential to enable social change. But this raises an important question — can we pool our ideas? ☐

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# THE DEEPEST VIEW OF THE UNIVERSE?

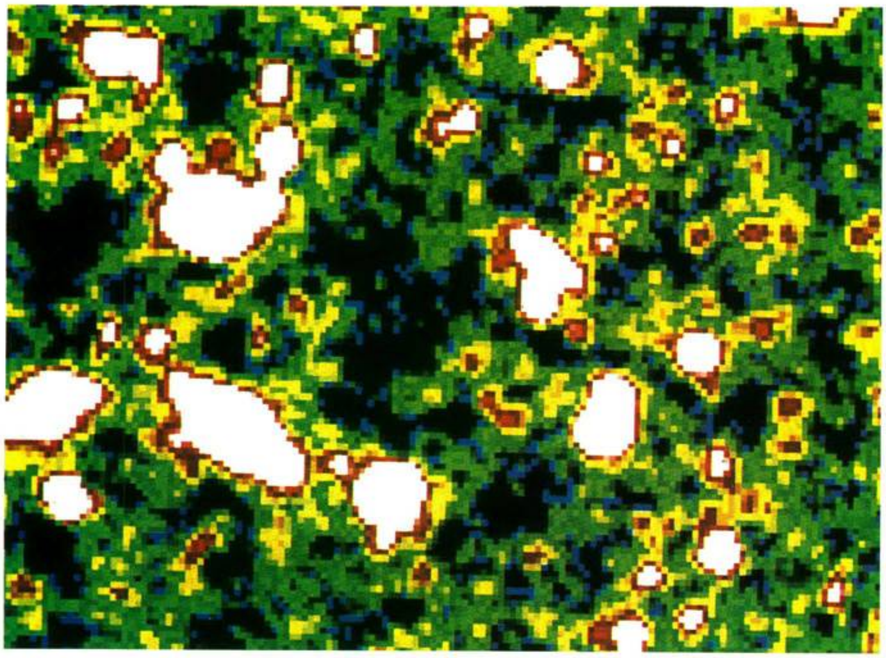
"The deepest view into deep space" was recently produced by astronomers using the European Southern Observatory's 3.6-meter New Technology Telescope at La Silla, Chile. The image, a composite of forty-one 10-minute exposures, shows a galaxy field in Sextans that includes objects as faint as magnitude 29.1. Astronomer Bruce Peterson of ESO made the series of images with a CCD detector on the ESO Multi-Mode Instrument.

It is a well established fact that most recorded objects fainter than magnitude 24 are not stars, but galaxies. In the Sextans image, more than 97 percent of the objects are galaxies, the brightest ones glowing at magnitude 21. The ESO image shows an incredibly dense background network of galaxies. The field of view is a mere 1.1' square, and this high density of faint galaxies packed tightly together is visible all over the sky. In this photo, however, the faintest galaxies shown are about 1 magnitude, or 2.5 times, fainter than any previously seen galaxies.

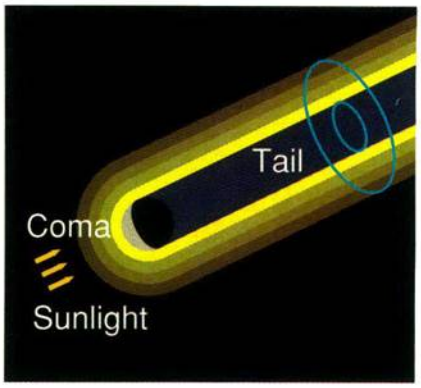
Earlier deep-space images showed that the number of galaxies increased as astronomers pushed their surveys toward fainter magnitudes and greater distances. Yet astronomers expected to find that at some great distance (corresponding to a time early in the universe's history), the number of galaxies would actually decrease because the time in question would be before most galaxies had formed. But the recent NTT image shows the number of faint galaxies is still increasing even at magnitude 29. This indicates that despite the new image's great distance penetration, astronomers have still not seen back to a time before the galaxies formed.

Just what types the galaxies in the NTT image are is uncertain. If the galaxies are dwarf ellipticals, they could have redshifts of 0.5 to 0.7 and be located some 10 billion light-years away. However, if they are normal spirals, they might have redshifts of 3.0 to 3.5 and therefore could lie at distances of about 18 billion light-years. If they are more massive and luminous yet, the galaxies would be even farther away. The data are at this point too uncertain.

The NTT image was made in yellow light. Further work will image these same galaxies in blue and red light, which may enable Peterson and his colleagues to determine approximate ages, distances, and types for the galaxies.



**THE FAINTEST GALAXIES KNOWN** are visible in this image made with the 3.6-meter New Technology Telescope at La Silla, Chile. European Southern Observatory photo.



**STREAMING LIKE A COMET,** a new-found cloud of sodium stretches out behind the Moon under the pressure of sunlight. Boston University graphic.

## THE MOON HAS A COMETLIKE SODIUM CLOUD

The Moon has been associated with a lot of things, but seldom comets. That's about to change. Recent observations of sodium in the lunar atmosphere by three astronomers at Boston University's Center for Space Physics have revealed that the cloud of sodium enveloping the Moon resembles that of a comet.

This discovery, announced at the American Geophysical Union's meeting in Baltimore adds evidence that the thin lunar atmosphere interacts dynamically with the interplanetary medium.

Astronomers Michael Mendillo, Jeffrey Baumgardner, and Brian Flynn found a sodium atmosphere extending more than two Moon diameters on the sunward side of the Moon. And pointing away from the Sun is a sodium tail about 10 lunar diameters long. The process pulling out the tail — electromagnetic pressure from the Sun — is also partly responsible for forming comets' tails.

Mendillo and his colleagues used a 4-inch telescope at the McDonald Observatory (near Ft. Davis, Texas), a CCD camera, and special filters to isolate the spectral emission line of neutral sodium.

The Moon's atmosphere is extremely tenuous — one estimate gives it as much gas as the Astrodome contains. It is comprised mainly of neon, helium, and hydrogen mostly captured from the solar

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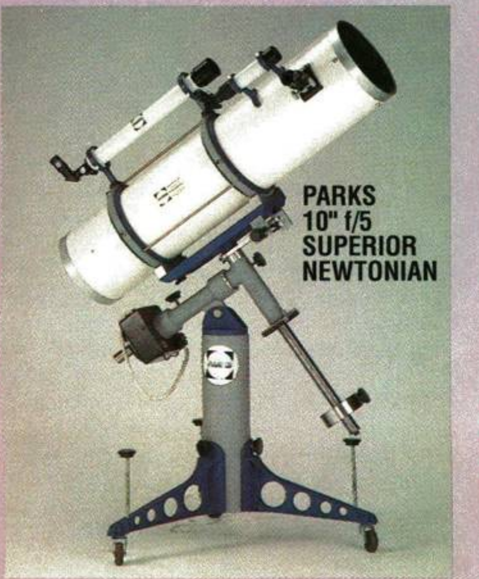

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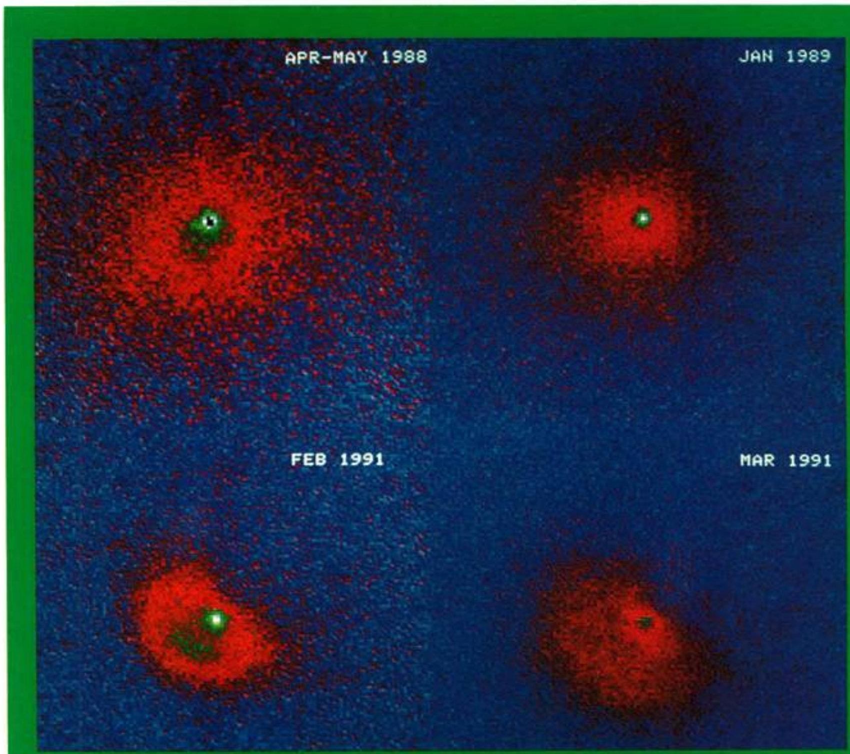
wind. Another major ingredient is argon, derived from the radioactive decay of elements in the lunar rocks. These gases eventually escape the clutches of the Moon's gravity, but are continually replenished from their sources.

In 1988, researchers found that sodium and potassium were important constituents of the lunar atmosphere. These elements apparently originate in the lunar rocks and soil and are released by meteorite impacts that vaporize small amounts of the lunar surface. Pressure from sunlight eventually overcomes the weak lunar gravitational pull and blows the elements away from the Moon. Yet as with the other elements, the continuing presence of a sodium cloud indicates some process is replenishing the supply.

That, says Mendillo, poses a tough scientific issue. The nature of the mechanisms that sustain this transient atmosphere begs many questions: What are the meteorite impact rates? How many sodium atoms are released and how quickly do they dissipate? Are other processes, such as sunlight and the solar wind, at work releasing the atoms from the Moon's surface?

Mendillo and his colleagues plan to continue monitoring the sodium cloud during all lunar phases and will try to construct mathematical models for the phenomenon. They also hope to extend their investigation to another key lunar atmospheric ingredient — potassium.

— *Shireen Gonzaga.*



**COMET HALLEY IN OUTBURST** is visible in this sequence made with the Danish 1.5-meter telescope at La Silla, Chile. The resulting cloud of dust is visible in the 1991 images as a fan-shaped shroud of red light. Astronomers have determined the outburst occurred approximately on December 17, 1990. European Southern Observatory photo.

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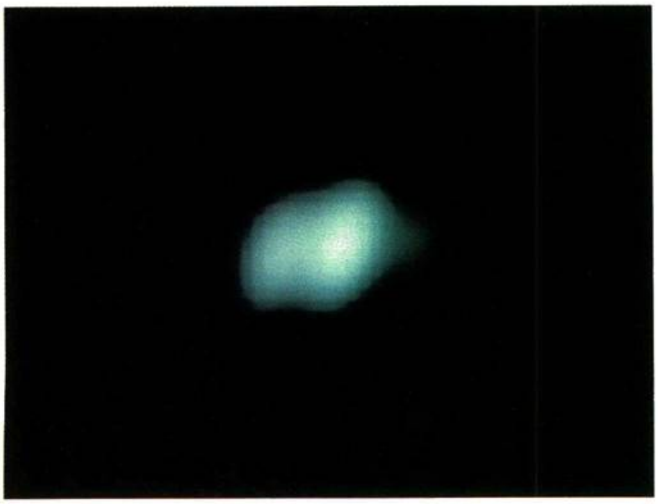
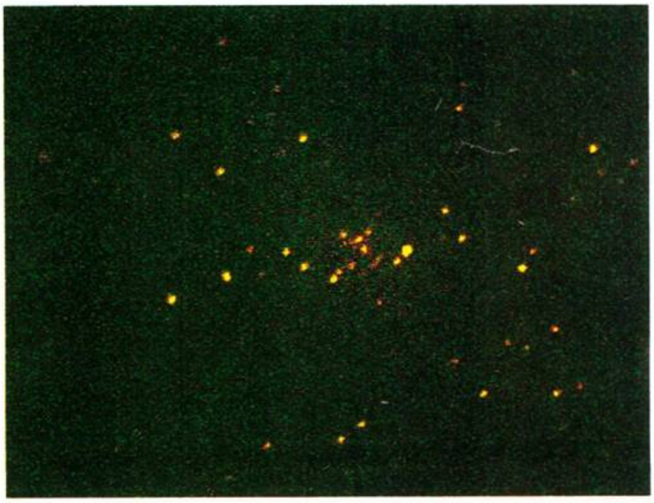


**THE FIRST LOOK AT THE GALACTIC CENTER** with the Very Long Baseline Array telescope shows the lobed structure of Sagittarius A*. The luminous part of this image is a region about 100 times the size of our solar system, and the brightest objects at center may be highly energetic gas surrounding a central black hole. Photo courtesy National Radio Astronomy Observatory.



**BRIGHT, VARIABLE X-RAY SOURCES** were discovered close to the center of the Andromeda Galaxy in data collected by the ROSAT satellite. Some sources seen previously by the Einstein satellite are now gone, and other new sources have appeared. This image shows 70 x-ray sources within 10' of the center of the galaxy. Photo courtesy Harvard-Smithsonian Center for Astrophysics.

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be a newborn galaxy or a quasar buried in a cloud of dust.

The object was first detected with the Infrared Astronomical Satellite (IRAS), which discovered hundreds of thousands of infrared sources during its ten-month mission beginning in 1983. A team led by Michael Rowan-Robinson of Queen Mary and Westfield College, London, discovered the object's high luminosity during a program to identify IRAS sources optically.

Using the 4.2-meter William Herschel Telescope on La Palma in the Canary Islands, the team found the object at visible wavelengths and determined its distance and luminosity. The team thinks it is a massive dust cloud glowing as a result of energy from one of two sources: a billion or so extremely hot, luminous stars formed early in a galaxy's life or a quasar more luminous than any ever seen that is hidden from view by the enshrouding dust.

## ASTEROID 1986 DA HAS A METALLIC COMPOSITION

A team of radar astronomers using the 1,000-foot Arecibo radio telescope as a radar antenna have found that asteroid 1986 DA has a radar signature indicating the body is metallic. The team, led by Steven Ostro of the Jet Propulsion Laboratory, reported their results in the June 7 issue of *Science*. 1986 DA orbits from just beyond Earth to just inside Jupiter and takes 4.7 years to make one circuit around the Sun.

The object is about 2 kilometers across. Says Ostro, "Its radar brightness is far greater than any of the 60 asteroids we have observed before or since. This supports our hypothesis that it is a large lump of iron, nickel, and other metals."

Ostro notes that although the object was observed five years ago, the team needed most of the time since to analyze the data, fitting it statistically into a population of observed asteroids. Only then was it clear that 1986 DA's radar reflectivity stood out as unusually high.

1986 DA is also extremely bumpy, possibly even multi-lobed like 1989 PB, which Ostro and his colleagues imaged two years ago. "1986 DA may be a relic of a larger body which came together, melted, separated into layers of dense metal and light rock, cooled, and was smashed apart in a collision with another asteroid," remarks Ostro.

# NASA WEIGHS NUCLEAR PROPULSION

One of the biggest obstacles to exploring the solar system is the time it takes spacecraft to travel to the planets. This obstacle, however, could be considerably diminished through the use of nuclear rocket engines. The high speed and fuel efficiency possible with nuclear propulsion could significantly reduce the travel time for interplanetary spacecraft.

With this in mind, NASA recently established a Nuclear Propulsion System Office at the Lewis Research Center in Ohio. Its goal is to develop a practical nuclear propulsion system for both manned and unmanned spacecraft. Because the project faces severe technological challenges and would have far-reaching impact, NASA isn't undertaking the program alone. Both the Department of Defense and the Department of Energy, which have been studying space nuclear power for the Strategic Defense Initiative, will join in the effort.

There are two basic types of nuclear propulsion technologies under consideration. One is called Nuclear Electric Propulsion, in which a nuclear fission generator produces electricity. The electricity powers ion thrusters, which expel a stream of hydrogen or argon plasma to produce thrust. The other option is Nuclear Thermal Propulsion. This technology would use the heat from nuclear fission to heat hydrogen to about 2500° Celsius and then expel the gas out a rocket nozzle.

According to Stanley K. Borowski, lead engineer for nuclear thermal propulsion at the Nuclear Propulsion System Office, nuclear rocket engines may be ready for space testing by the first decade of the 21st century. Some of these test flights, Borowski suggested, might be used to launch unmanned spacecraft toward the outer solar system. Operational versions of the systems for manned spacecraft could be ready as early as 2010.

Nuclear propulsion technology would benefit the space program in two important ways. First is the economic factor. Nuclear rocket engines are more efficient than conventional chemical rocket engines. They produce more thrust with less fuel than conventional chemical rockets, which translates into greater payload capacity.

Then there is the all-important issue of safety. Nuclear rocket systems, according to Borowski, will make manned interplanetary travel safer for astronauts. Space is a hostile environment for human beings. Radiation, both from the Sun and from deep space, pose a constant threat to humans in space. In addition, zero-gravity is harmful to human physiology when experienced for months at a time.

A nuclear thermal propulsion system, with its high thrust, can cut the travel time between planets and thereby reduce the time astronauts are exposed to the hazards of interplanetary space. According to research done at the Massachusetts Institute of Technology, a manned spacecraft using nuclear rockets would require only 150 to 300 days to travel to Mars and back. In comparison, a manned craft using conventional chemical rockets would require 450 to 500 days for a round trip.

The potential benefits of nuclear propulsion systems are so great that a White House research committee strongly recommends that nuclear propulsion be used for the manned exploration of Mars. Chaired by ex-astronaut Tom Stafford, the committee prepared four scenarios for manned exploration of Mars, and all require nuclear propulsion to succeed.

Not all of the hurdles facing space nuclear power systems are technical in nature. Some of the most daunting may be social and political. There are several powerful anti-nuclear groups that are likely to object to any project that would place more nuclear reactors in space. These groups sought court injunctions to prevent NASA from launching the Galileo and Ulysses space probes, which carried small nuclear generators to produce electricity.

Though they were unsuccessful in grounding Galileo and Ulysses, anti-nuclear groups are sure to take action against the development of nuclear propulsion technologies. Their success or failure will be determined as much by public opinion as by the safety and reliability of the new nuclear propulsion technologies. — *Robert G. Nichols*

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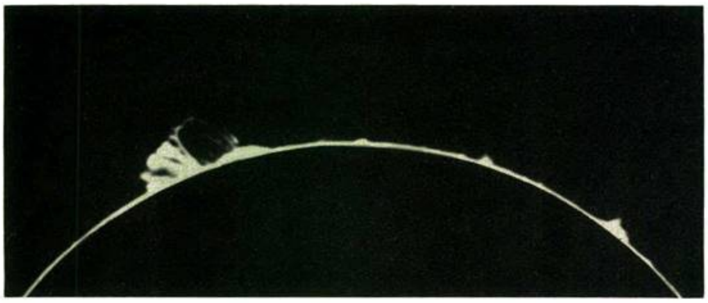

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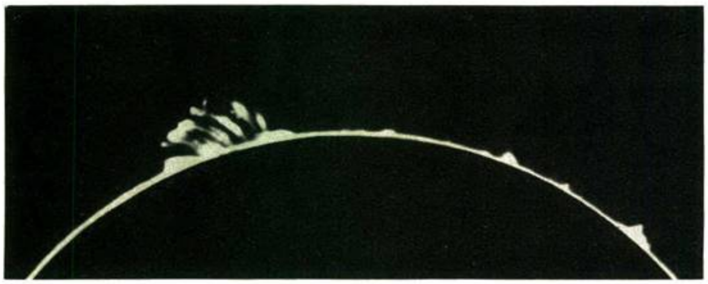

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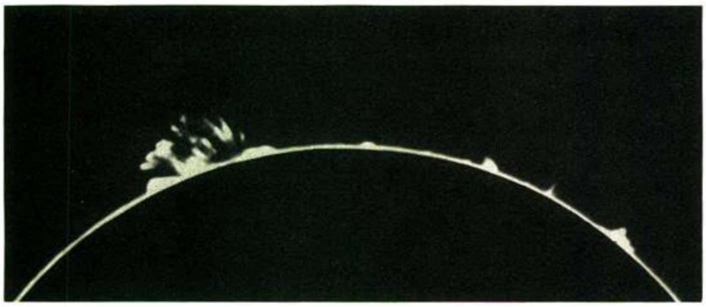

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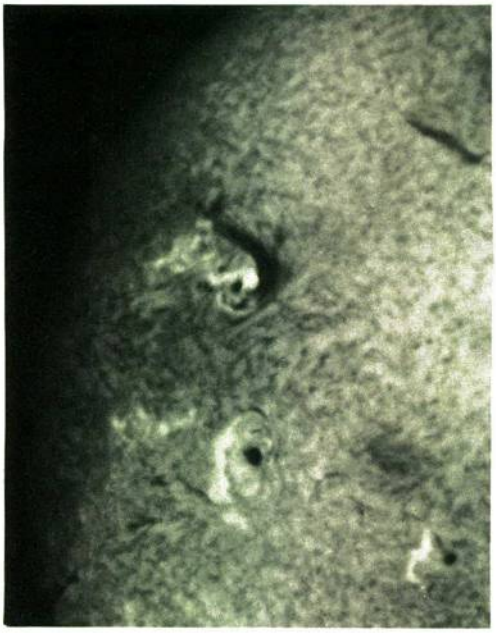

*Solar flare with surge prominence.*

# AN ASTRONOMY ROUNDUP IN LARAMIE

Laramie, Wyoming, probably wouldn't make most lists of major astronomical research centers. But in the eyes of infrared astronomers, Laramie is one of the hottest places in the business. Formerly a town on the frontier of the West, Laramie is now one of the prime sites for research on one of the frontiers of astronomy, infrared studies. This past June, the University of Wyoming was also host to a week-long conference attended by approximately 350 amateur and professional astronomers as well as astronomy educators from the local area.

The occasion was the 103rd annual meeting of the Astronomical Society of the Pacific, an organization that caters to the interests of both amateur and professional astronomers. The conference included sessions for educators on teaching astronomy in the classroom. One highlight was a talk by science writer Timothy Ferris (*The Red Limit, Coming of Age in the Milky Way*) who spoke on his experiences producing TV science documentaries such as *The Creation of the Universe.* According to Ferris, "Science programs are competing with the production values set by MTV, ads, and feature films. The audience is there — we're simply not effective in reaching them."

Contrasting with the educators' sessions were symposia geared for the professional researchers. These included sessions reviewing the state-of-the-art in automated telescopes. It was obvious that these robot telescopes that spend the night gathering data under programmed commands are the way of the future for many areas of research. Being able to grab hundreds of spectra or images of the sky per night has exciting implications for measuring the structure of distant galaxy clusters, monitoring changes in the brightness of stars and galaxies, and conducting sweeping surveys of the sky.

Conference attendees also got a glimpse of the future as astronomers discussed the prospects for robot telescopes on the Moon. As Jack McGraw of the University of Arizona put it, "The Moon is an excellent spacecraft." If the many designs for lunar telescopes discussed at the conference make it off the drawing board, the Moon will certainly become *the* site for astronomical research in the 21st century.

Meanwhile, astronomers are surprising even themselves with the progress they're making at improving ground-based telescopes. This was evident at the session on the state of high-resolution imaging with Earth-bound scopes. Adaptive optics was the buzz word. There was clear excitement in the air about the success astronomers are having at beating back the blurring effects of poor seeing. For example, René Racine of the University of Montréal told of work at the Canada-France-Hawaii Telescope. Using a first-generation adaptive optics camera, CFHT astronomers have been able to reduce the blurring effects of the atmosphere enough to resolve stars in galaxies 50 million light-years away, a feat thought to be the domain of the Hubble Space Telescope. Racine and his colleague Robert McClure were awarded the Astronomical Society of the Pacific's Muhlmann Prize for outstanding work carried out at the observatories on Mauna Kea.

As with robot telescopes on the Moon, the new technology of adaptive optics promises to revolutionize astronomy. Conference delegates heard sober astronomers speak blithely of using laser beams and "rubber" mirrors to achieve diffraction-limited resolutions from ground-based telescopes. This scheme would have been labeled crazy only a few years ago when Hubble was on the drawing board.

The future of astronomy was very much a theme this year, with members of the Bahcall Committee presenting the astronomical commun-ity's statement of priorities for government funding of astronomy in the 1990s. In keeping with the Wyoming location, infrared was the buzz word in *this* report. Big ticket projects include (in order of priority) SIRTF (the yet-to-be-funded Space Infrared Telescope Facility), an infrared optimized 8-meter ground-based telescope (to go on Mauna Kea), a millimeter-wave array of radio/infrared dishes, and a Southern Hemisphere twin to the Mauna Kea 8-meter. Heading the list of more moderately priced projects were development of (what else!) adaptive optics technology and SOFIA, a 2.5-meter telescope to be mounted in a Boeing 747 for airborne looks at the infrared universe. If astronomers get their wish list fulfilled, the 1990s promises to be the "infrared decade."

As is always the case at each A.S.P. meeting, amateur astronomers also had a full program of activities. Members of the Cheyenne Astronomical Society held a star party with everything from small refractors and CCD-equipped Schmidt-Cassegrains to big Dobsonians out and available for viewing under the crystal clear Wyoming skies. During the day, Jack Newton discussed his astrophotography techniques, Tim Hunter reviewed progress in combating light pollution, and astronomers Larry Esposito, Alex Filippenko, Virginia Trimble, and Michael Zeilik reviewed our state of knowledge on topics as diverse as extra-solar planets, supernova 1987A, dark matter, and astro-anthropology.

As part of this popular lecture series, Richard Berry, Editor-in-Chief of ASTRONOMY, presented a behind-the-scenes look at how the magazine is put together. Richard and the staff of ASTRONOMY were honored with the A.S.P.'s Klumpke-Roberts Award for contributions to the popularization of astronomy over the years. Other awards presented at this year's conference included the A.S.P.'s Amateur Achievement Award, which went to Otto Kippes, a German amateur astronomer, for his long-term program of variable star observations, and a lifetime achievement award, the Catherine Wolfe Bruce Medal, presented to Donald Oster-brock of the Lick Observatory.

Next year's meeting of the Astronomical Society of the Pacific will be at the end of June in Madison, Wisconsin. As with Laramie, it's a long way from the Pacific, but the A.S.P.'s membership now extends far wider than just the West Coast. Midwest astronomers in particular are invited to a meeting that each year is unique in combining the excitement of new results from professional research with the enthusiasm and curiosity of amateur astronomers. □

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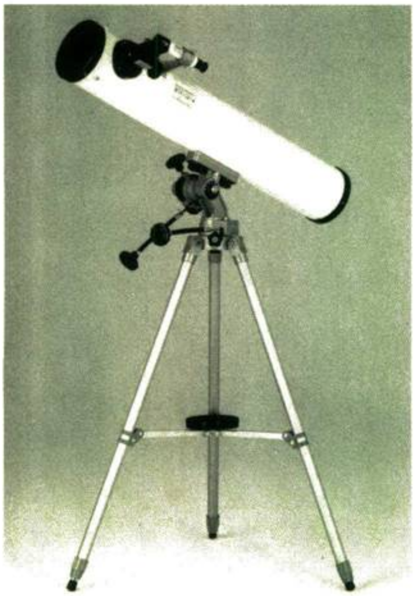

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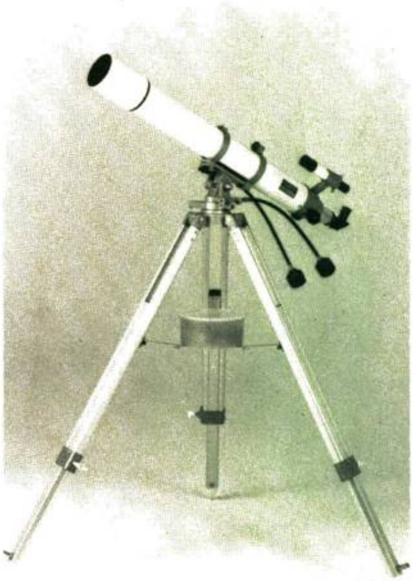

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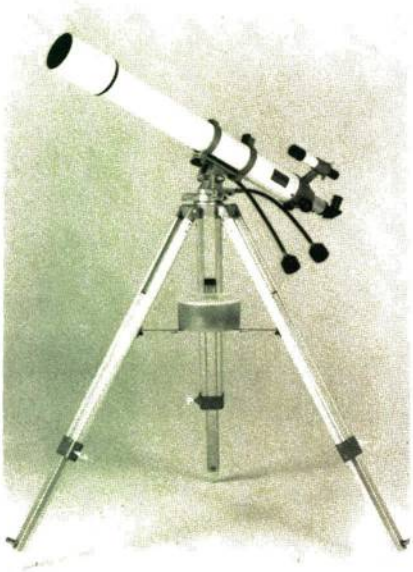

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# GLORIOUS UNIVERSE

***The evolving universe is a vast, magnificent canvas on which we find ourselves occupying just the smallest of corners — but it's a highly interesting corner all the same.***

All the matter, space, and time there ever has been or ever will be popped into existence 10 to 20 billion years ago.

This tiny, supercompressed point — a "singularity" in the jargon of physicists — was unimaginably hot and packed with energy. It burst forth in a titanic explosion and, expanding and changing ever since, it has become the universe that we — and who knows who else? — call home. If some cosmologists are right, it's the only universe there ever has been, but there's no way of knowing for sure. All they can say is that the universe is expanding much too fast to stop. Like a solidly hit fast ball, the Big Bang is going — going — gone.

But there's much yet to happen before everything flies over the outfield fence. Whirling galaxies will spark star-fire from drifting dust motes and volatile gas. Generations of stars will live and die; solar systems will form and evolve; worlds will be born. The full-color spectacle of the universe at work will fill the night with light, even as the voids between the galaxies grow larger and darker.

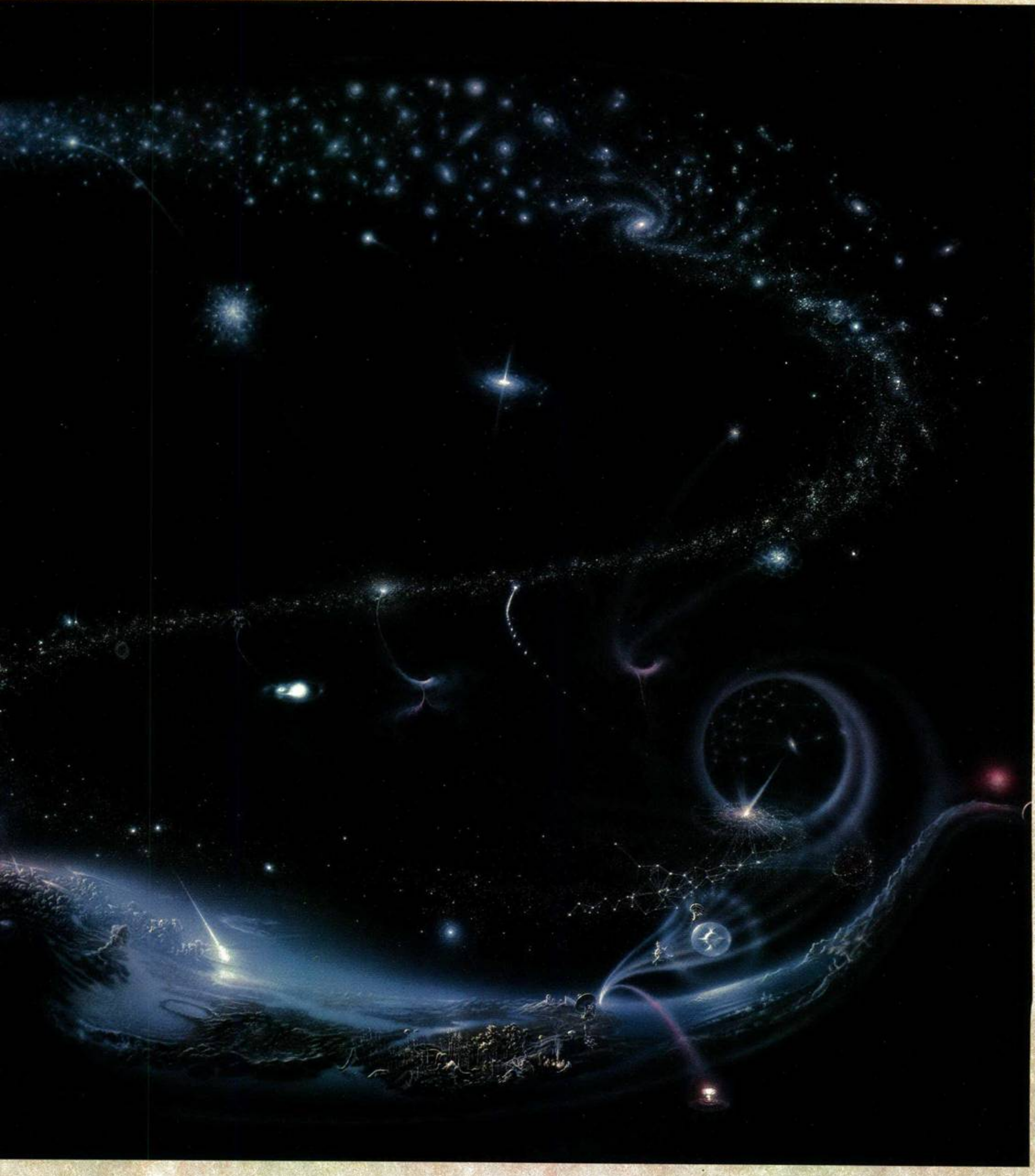
Eventually, however, the grand machine will run down. Eons from now, the last stars will grow cold and the galaxies will disperse. But the story may still not be over — matter itself may continue to evolve, with seemingly stable atoms becoming senile and spontaneously disintegrating.

What is the ultimate fate of the universe? That question is as mysterious as where the Big Bang itself came from — and just as unanswerable.

## BEGINNINGS

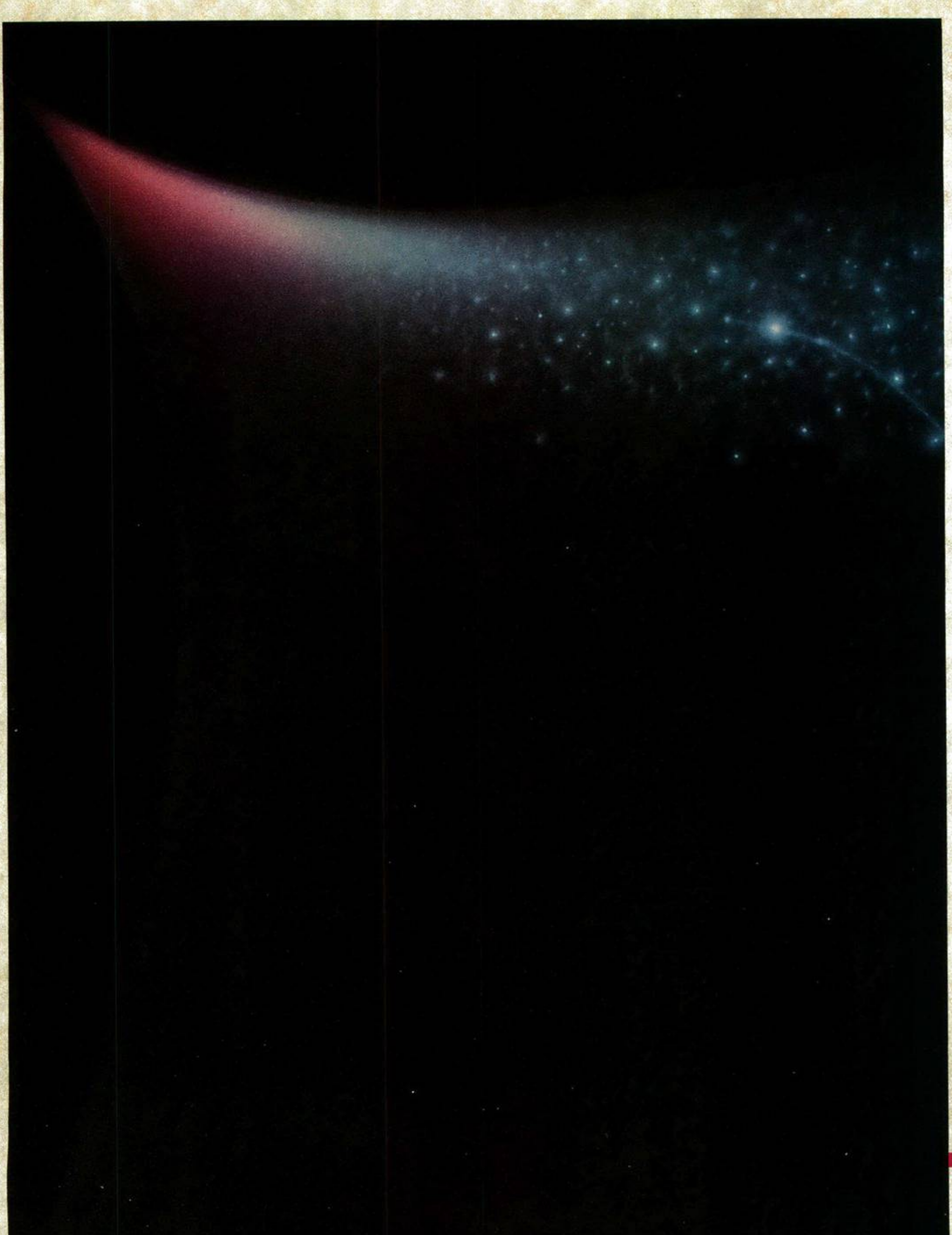
Every astronomer knows that as telescopes look deeper into the universe, they also look deeper into time past. Moonlight is 1.3 seconds old when it spills across the floor of your living room, while sunlight ages 8 minutes in the time it takes to travel to Earth. The soft light of the Great Galaxy in Andromeda, rising in the northeast these evenings, is over 2 million years old.

But the oldest light of all isn't even light as we think of it. It is a very faint radio hiss that comes from every direction, all at once. This "light" is the fading fireball of the Big Bang, the cooling fire of creation, and it poses



By Robert Burnham

Illustrated by Adolf Schaller



a problem for cosmologists because it is very, very smooth. No matter where they aim their instruments, the hiss sounds exactly the same. The smoothness of the hiss shows that the Big Bang was the tidiest, most well-mannered explosion that ever was — and yet soon after the Bang, galaxies appeared. Where did they come from? Gravity could build a galaxy quickly, but it has to have a seed to start with. The seed could be either a slightly denser clump of matter or a wrinkle in the explosion. Cosmologists argue over the observations, which seem to show that the early Big Bang had neither, and they construct elaborate theories from which galaxies spring forth instead out of such arcana as cold dark matter, false vacuums, or quantum tunneling.

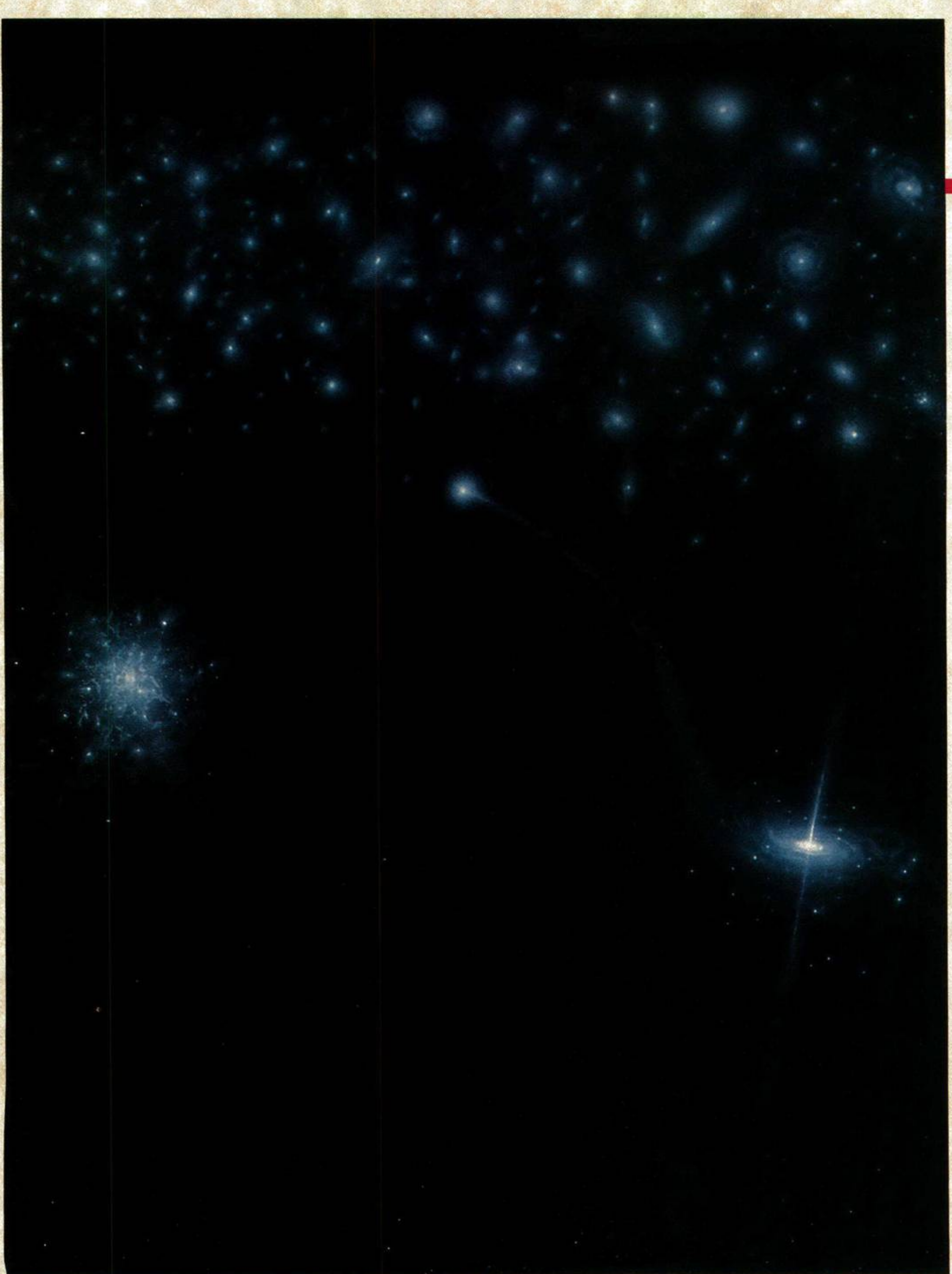
But while cosmologists puzzle over how the universe made something out of (almost) nothing, the arrangement of galaxies also harbors unanswered questions. Why do they group into clusters, clusters of clusters, and even higher orders of organization? Every time astronomers push a survey to greater distances and encompass larger volumes of space, they find ever-larger structures — filaments, giant curving sheets and strings of galaxies, enormous yawning voids — until the very fabric of the universe seems packed with foamy soapsuds.

Other questions emerge when astronomers examine the most distant galaxies. Those nearer in time to the Big Bang look different from those close to Earth. The earliest galaxies seem to have strong central engines beating in their hearts: quasars, which fountain energy at rates the universe

***HOW DOES A GALAXY GROW?***

*Astronomers do not yet understand how large organized structures like galaxies arose from an extremely smooth Big Bang.*

***SHROUDED IN COSMOLOGICAL MYSTERY,*** *the time right after the Big Bang contained the seeds of everything — stars, nebulae, and galaxies — that has followed.*



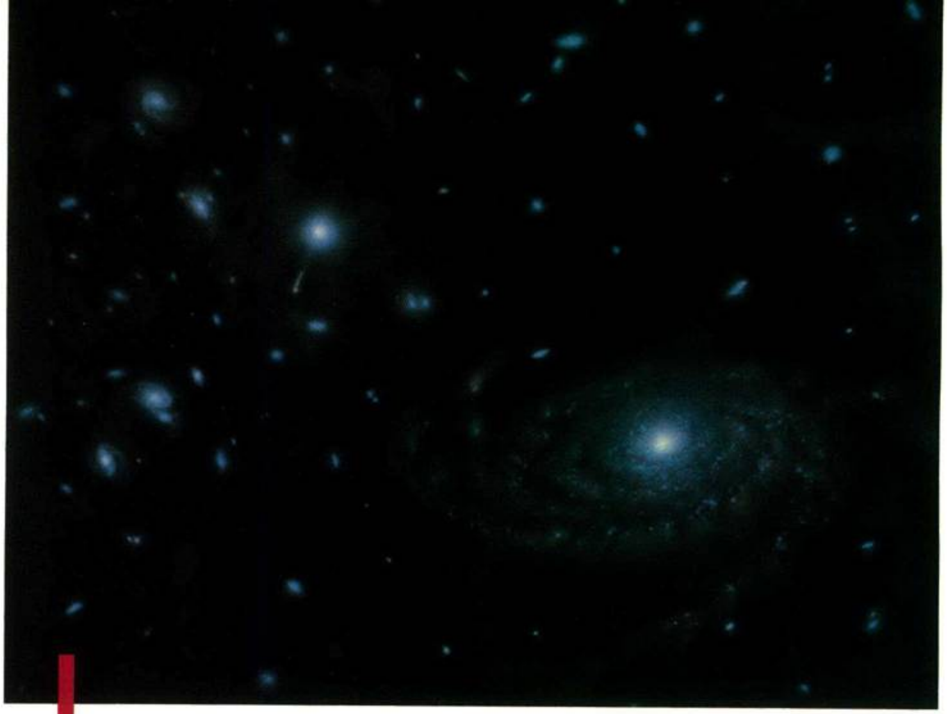
***THE COSMIC ARCHITECTURE***

*contains galaxies, clusters of galaxies, and clusters of clusters. Where do the congregations stop?*

has never seen since their heyday. Discovered thirty years ago, quasars are now thought to be black holes devouring material in the crowded centers of their host galaxies. Squeezed and heated by tidal forces beyond comprehension, the tortured matter flashes fierce radiation before it vanishes forever into the black hole.

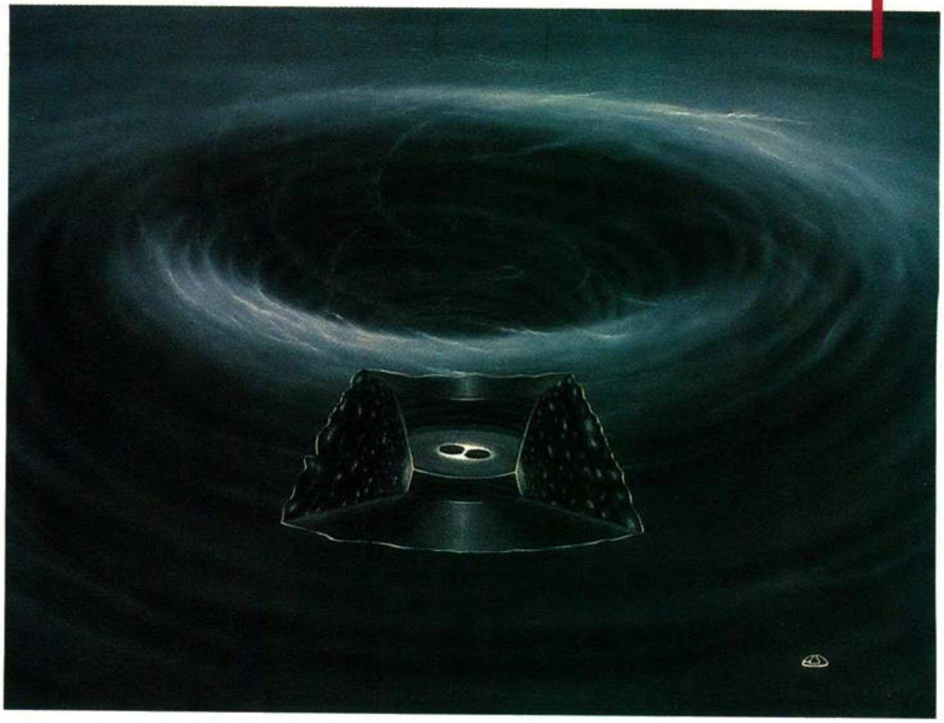
Between the distant quasars and the stars of the Sun's neighborhood lies a vast middle ground where the architecture of the cosmos stands in full display. Far from scattering at random as astronomers once surmised, galaxies tend to congregate, as people do. Moreover, their congregations also congregate, and so on. These vast clouds of organization — in which galaxies behave like swarming dust motes — have taught astronomers that there's much more to the universe than meets the eye. An astronomer can examine a galaxy and from its brightness make a guess as to how many stars and how much dusty gas it contains. Yet when we track the movements of galaxies in a self-contained cluster, they move as if each galaxy were far heavier than it appears. It's like watching go-carts move as unstoppably as trucks. What is this mass that looms invisibly among the bright lights of the galaxies? No one knows.

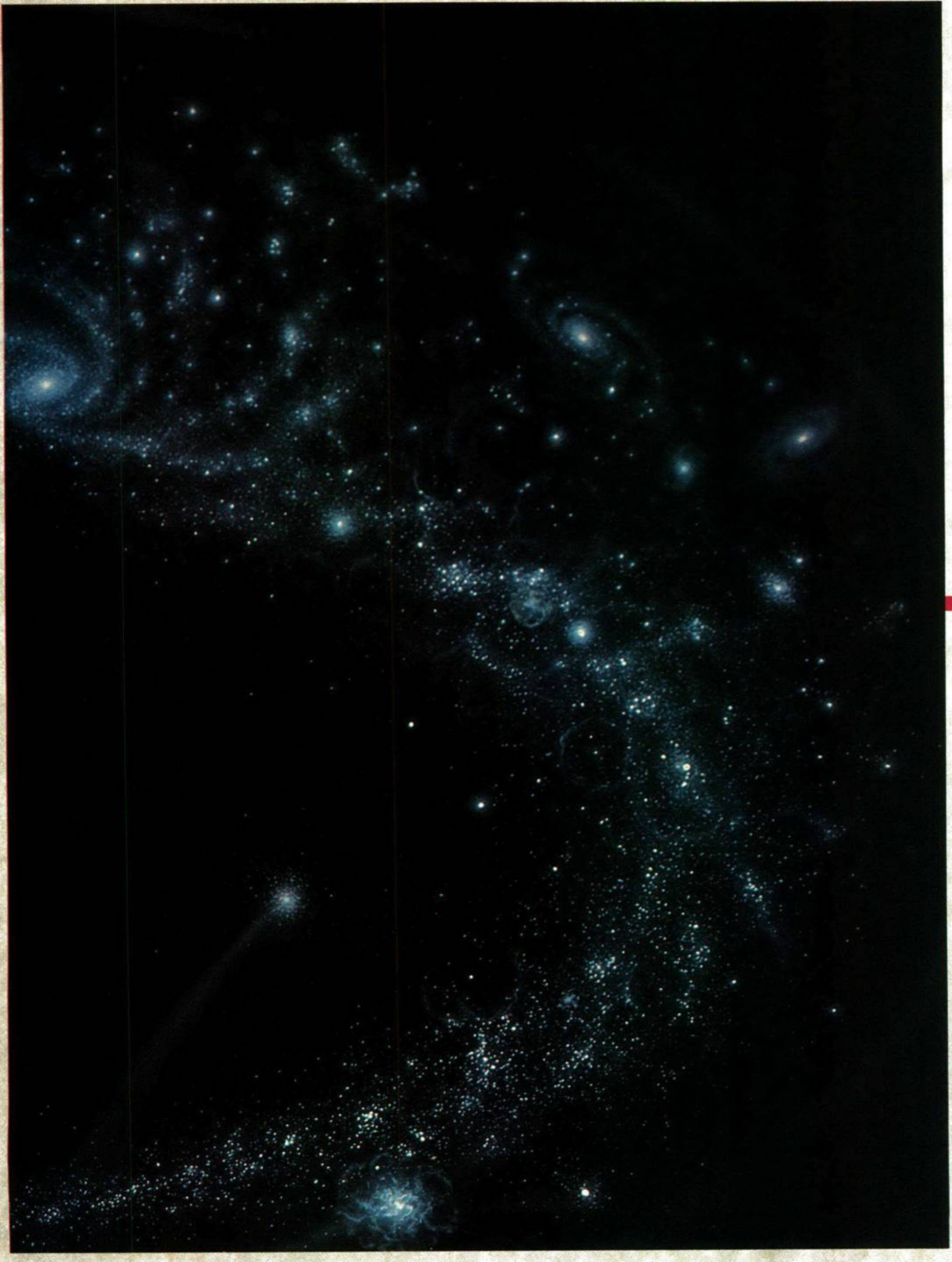
The galaxies themselves pose puzzles. Why are there only two main kinds, spiral and elliptical? What determines which kind a galaxy will become? The Milky Way is a spiral galaxy; these account for about a third of the total. Spirals have central bulges with old reddish stars surrounded by spiral-armed disks filled with young stars and the dusty gas from which they were made. Ellipticals, on the other hand, are often larger but contain little except older yellow and red stars. Lacking the abundant gas to make

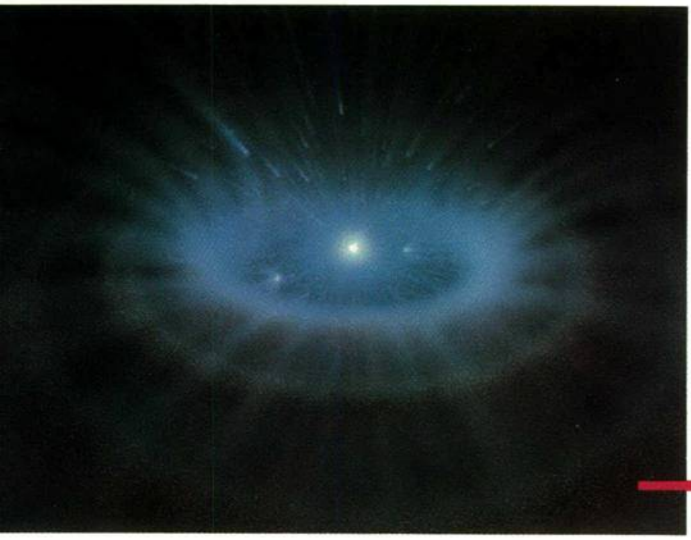


***THE FIRST STARS AND THE GALAXIES*** *were made entirely of hydrogen and helium. Everything else, including the heavier elements we are made from, had to be created in this first generation of stars.*

***THE ENDS OF STELLAR LIVES*** *are many. One such is the neutron star, the fate of most massive stars. If a neutron star is surrounded by a disk of gas and dust, it may flash into temporary brilliance as material falls onto its surface and detonates with multi-megaton force.*

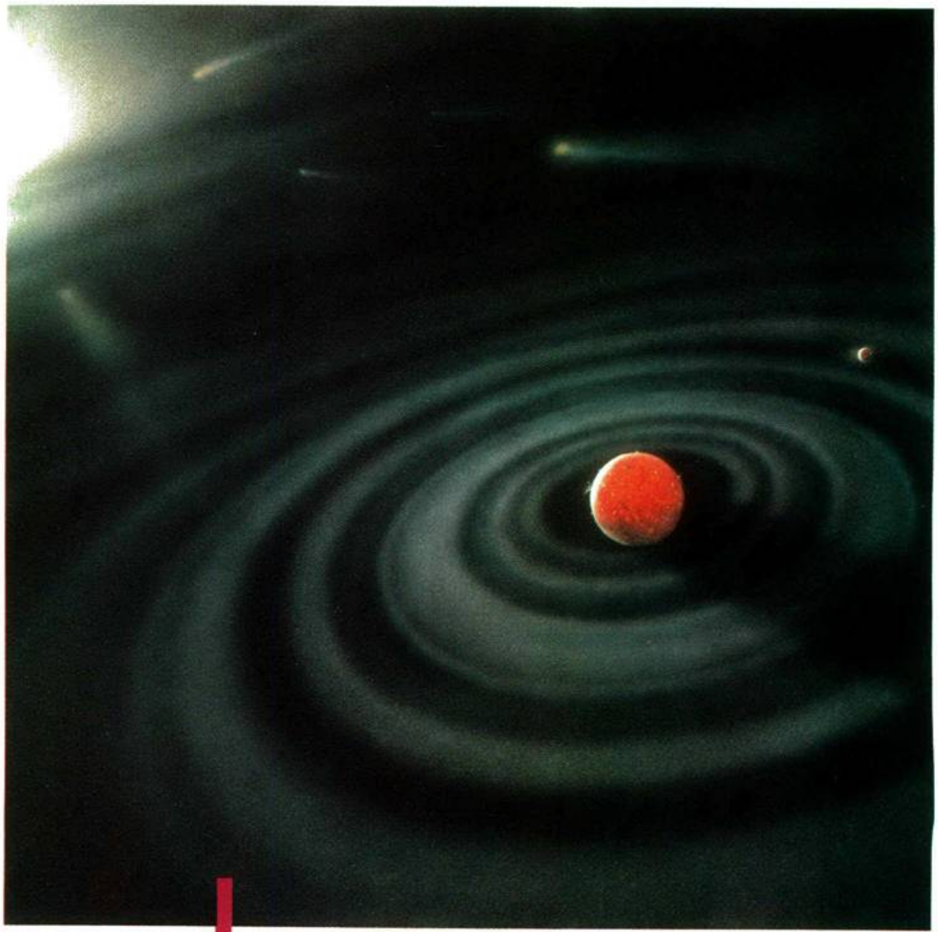






***A FIERCE "WIND" STRIPPED** the inner solar system of gas and dust when the early Sun ignited its nuclear fires for the first time.*

***A SHOCK WAVE MAY TRIGGER** stars to form in a spiral arm when it races through a cloud of galactic gas, dust, and molecules. This push is enough to start the cloud collapsing, and its largest lumps will form the first stars.*



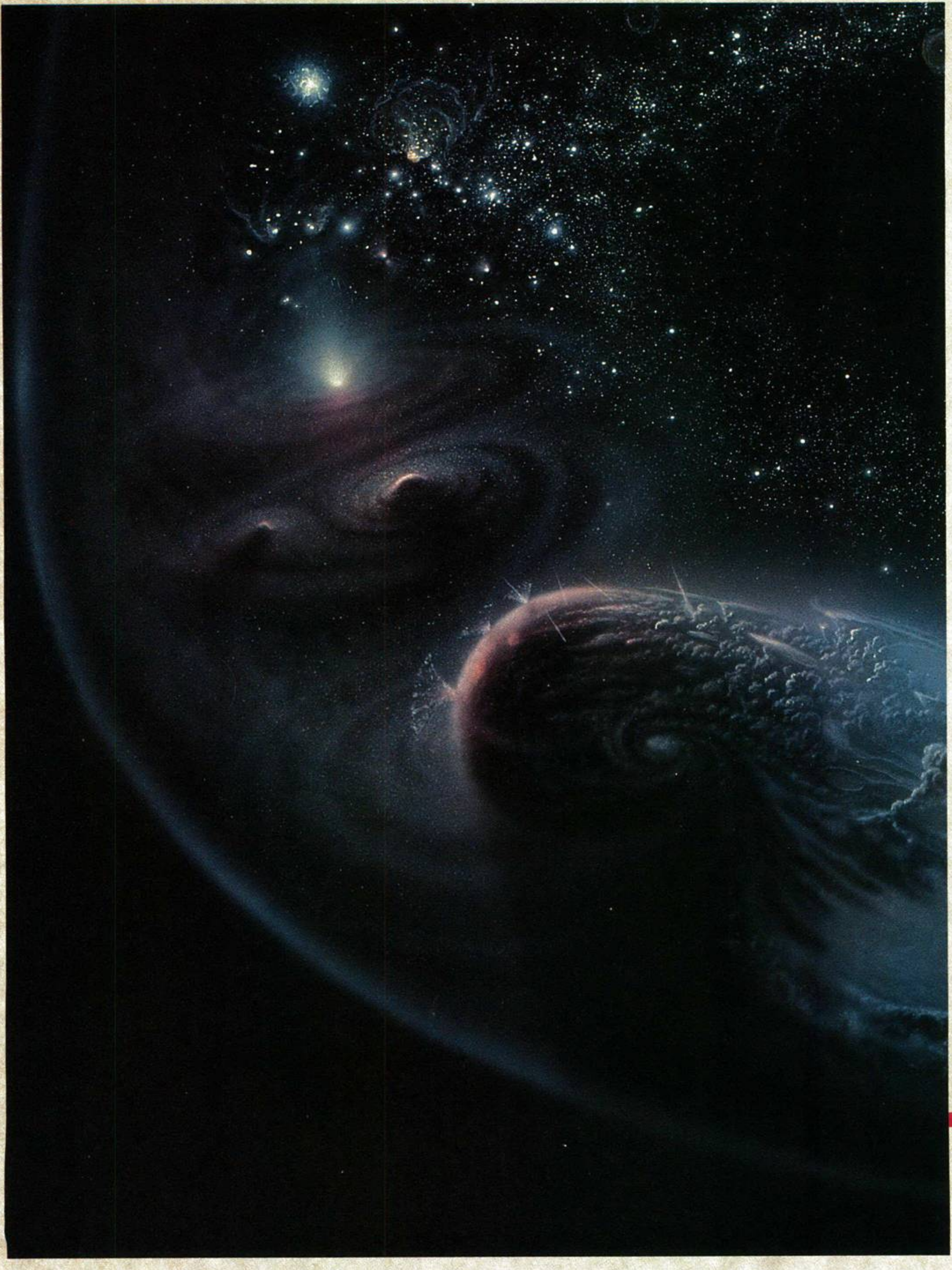
***THE EARTH HAD A HOT AND VIOLENT BIRTH** at the heart of a cloud of debris which rained ceaselessly upon it for millions of years.*

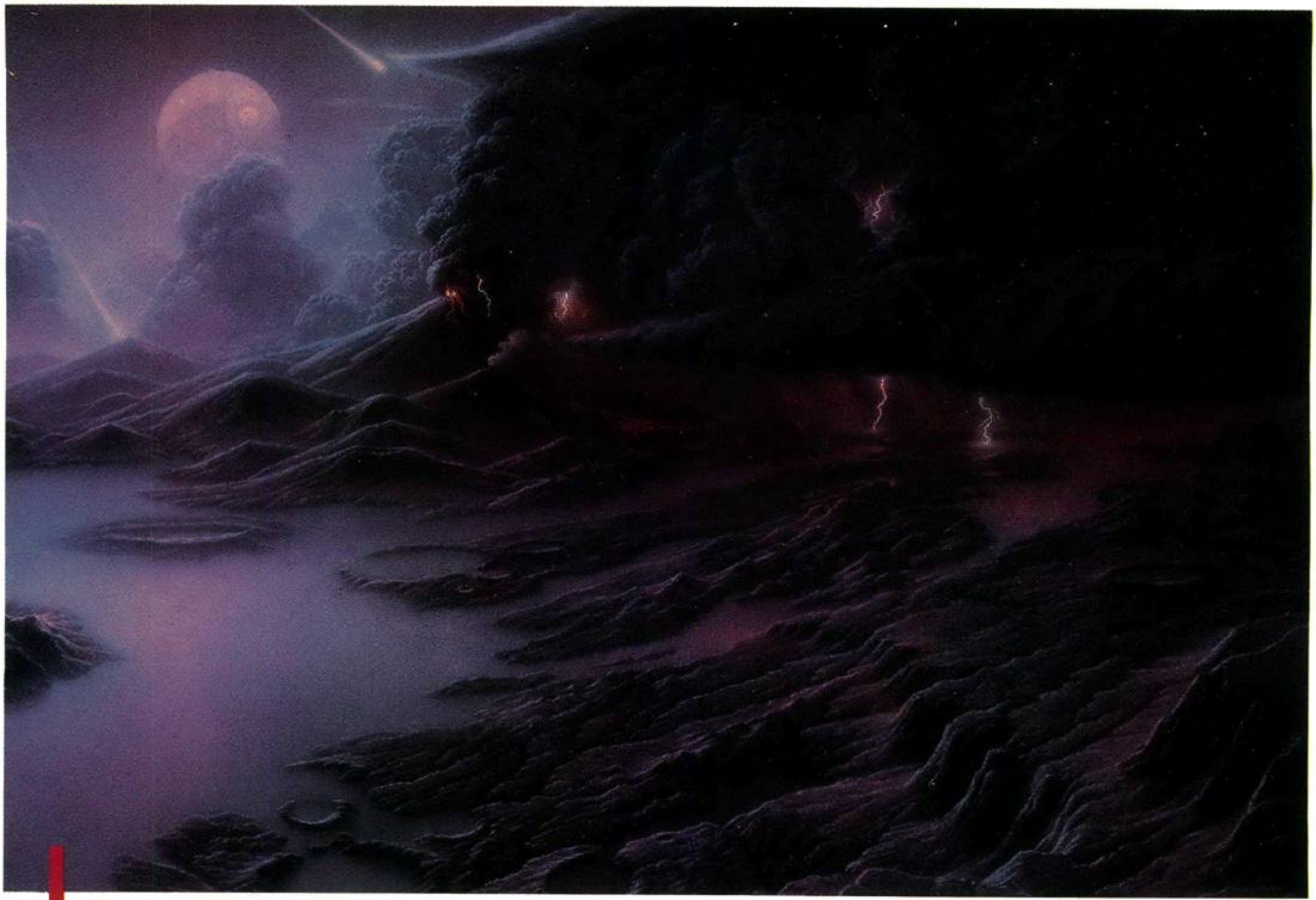
more stars, these galaxies are doomed to a sterile future, growing older and colder with little hope of new star-life to rejuvenate them.

### FACTORIES OF THE COSMOS

Spiral galaxies are nature's star-making machines. The seat of action in a spiral such as the Milky Way or the Andromeda Galaxy is the disk, the platter-shaped home of unnumbered stars and clouds of gas and dust. Sweeping round in a spiral pattern that endures for millions of years, shock waves in the disk periodically nudge the dust and gas. Jolted out of stasis, knots of gas begin to contract under gravity and grow warmer as their particles jostle one another. The knots eventually grow hot enough to light thermonuclear fires in their centers and become stars. Then, like new-lit lamps hung on a carousel, these drift onward through the night, orbiting the distant galactic center.

In time the larger stars race through their fuel and begin to die. Some become red giants — bloated gasbags whose outer envelopes are cool, filmy tissues of elements and molecules, easily lost to space. The biggest stars explode with titanic fury, throwing off their processed star-stuff into space in the wake of a





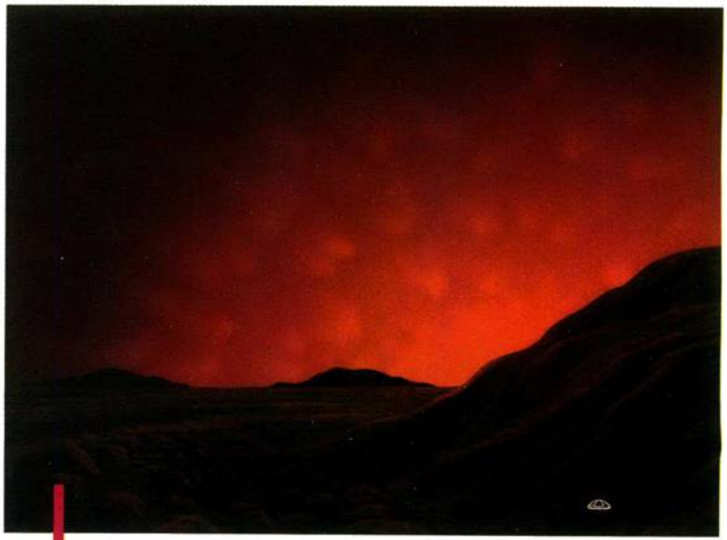
***THE EMERGENCE OF LIFE*** *was the most important event in Earth's history, but we know very little about the specific conditions under which it began.*

supernova. Ripping through dense clouds, the blast waves of supernovae may trigger new rounds of star-making. Our Sun is a second-generation star, born from stellar castoffs and hand-me-downs. It contains many elements — iron, oxygen, carbon, gold — that did not exist when the universe was new. To make the Sun, these elements had to be forged in the furnaces of older stars and broadcast back into space when those stars' lifelines drew to a close.

### DEAD STARS' SOCIETY

Earth, Sun, and solar system were born together 4.5 to 5 billion years ago from an interstellar nebula of dusty gas. Laced with the debris of dead stars, the pre-solar nebula was parent to nearly everything in our lives, including warm sunlight, the blue sky overhead,

***MAKING PLANETS MAY BE ROUTINE*** *or it may be rare, but the recent discoveries of material around nearby stars encourages astronomers to think that solar systems may be fairly common in the Milky Way Galaxy.*



***A STAR IS NOT FOREVER*** *and our Sun is no exception. One day, evolution will turn it into a red giant. With a surface reaching past the orbit of Venus, the swollen Sun will devour its inner planets.*

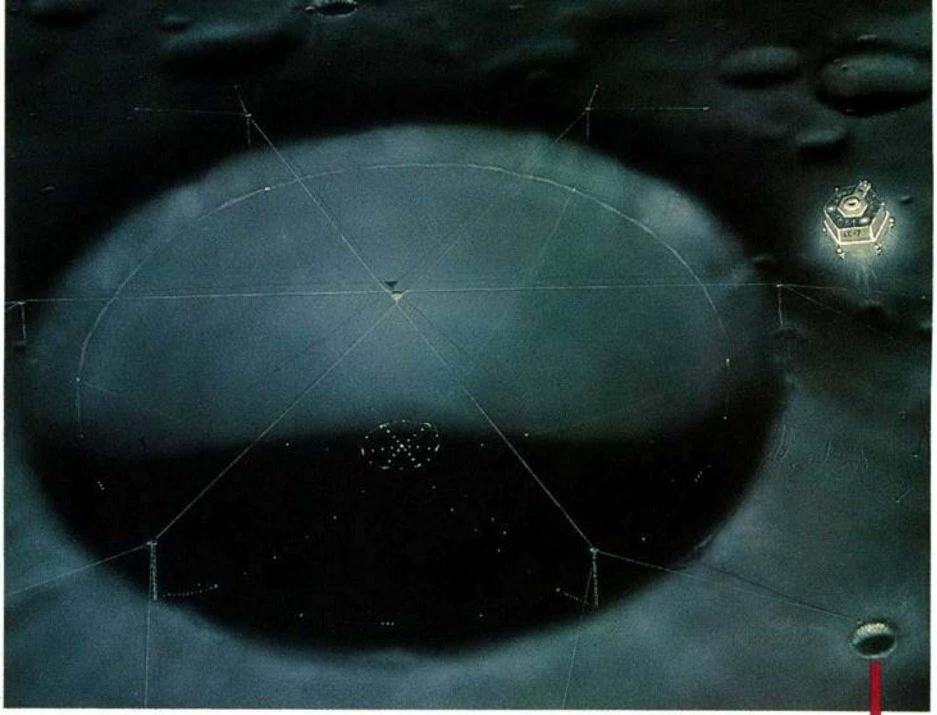
***EARTHLY LIFE THRIVES** wherever it finds a niche and this gives hope that we might find it elsewhere in the universe.*

and ourselves. Early Earth, however, was a hostile place — hot, repeatedly struck by asteroids, and shrouded in a choking atmosphere that would destroy us today. At a point perhaps 3.5 billion years ago, life began on Earth. Or it may have begun many times, destroyed by cataclysms each time but the last. Whether it formed in pools of water, as a skin on rocks, or in some other environment we can scarcely envision, life thrived and changed in response to its surroundings, always seeking a better metabolic fit between itself and the world. Where an organism's capabilities matched the demands of the environment, it reproduced and spread. Where the fit was poor, organisms died out.

Blindly, haphazardly, randomly chasing the paired grails of greatest reproductive success and least bodily insult, life evolved by fits and starts amid conditions that swung from the pleasantly benign to the immediately lethal. At least a dozen times, planet-wide ecological crises wiped out large fractions of all living organisms. Some crises may have been caused by the impacts of giant meteorites and others by reasons yet unknown. But in the aftermath of each crisis, life spawned wonderfully diverse assortments of new creatures. These quickly occupied newly vacant niches in the food chains and settled into a normal existence in which new species occurred relatively rarely.

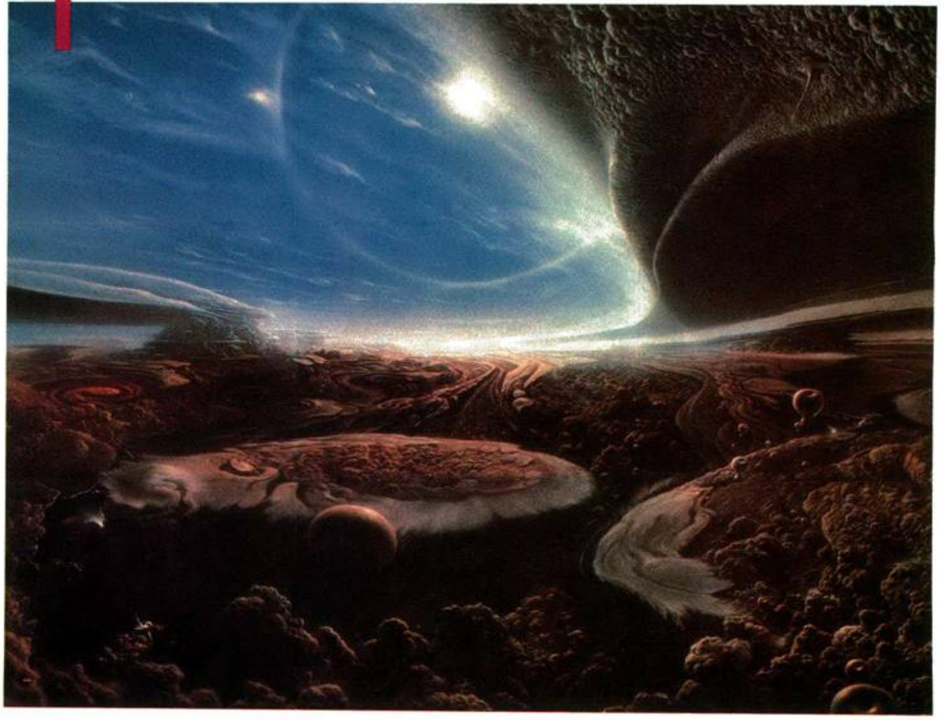
## FROM TRILOBITES TO TRITON

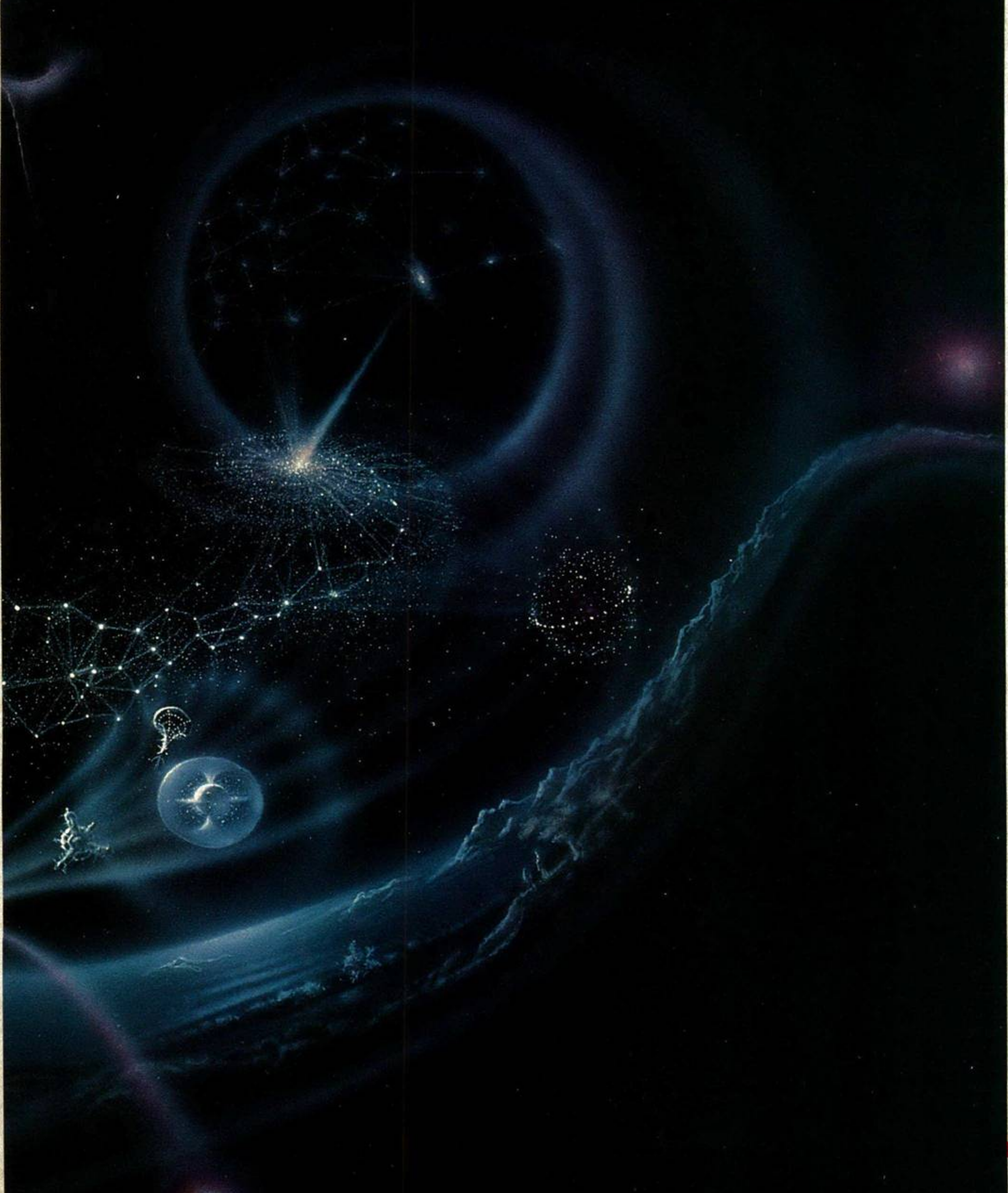
Many times in Earth's biological history, life has abruptly taken a step forward in complexity. The first step, after the origin of life itself, was the evolution of single-celled creatures. The second was the appearance of multicelled life, about a billion years ago. Other giant steps followed as millions of years rolled by. First trilobites, then the earliest land creatures, and fi-



***A LUNAR ARECIBO RADIO TELESCOPE** on the Moon's farside could probe deeper into the cosmos, free from manmade interference.*

***DOES LIFE EXIST ELSEWHERE?** The solar system looks barren except for Earth, and yet scientists note that a drifting aerial form of life could exist in the warm cloud layers on Jupiter. And beyond the Sun? That's anyone's guess.*





nally giant reptiles appeared. The last major change, to mammalian-dominated life after the dinosaurs' demise, leaves us as the inheritors.

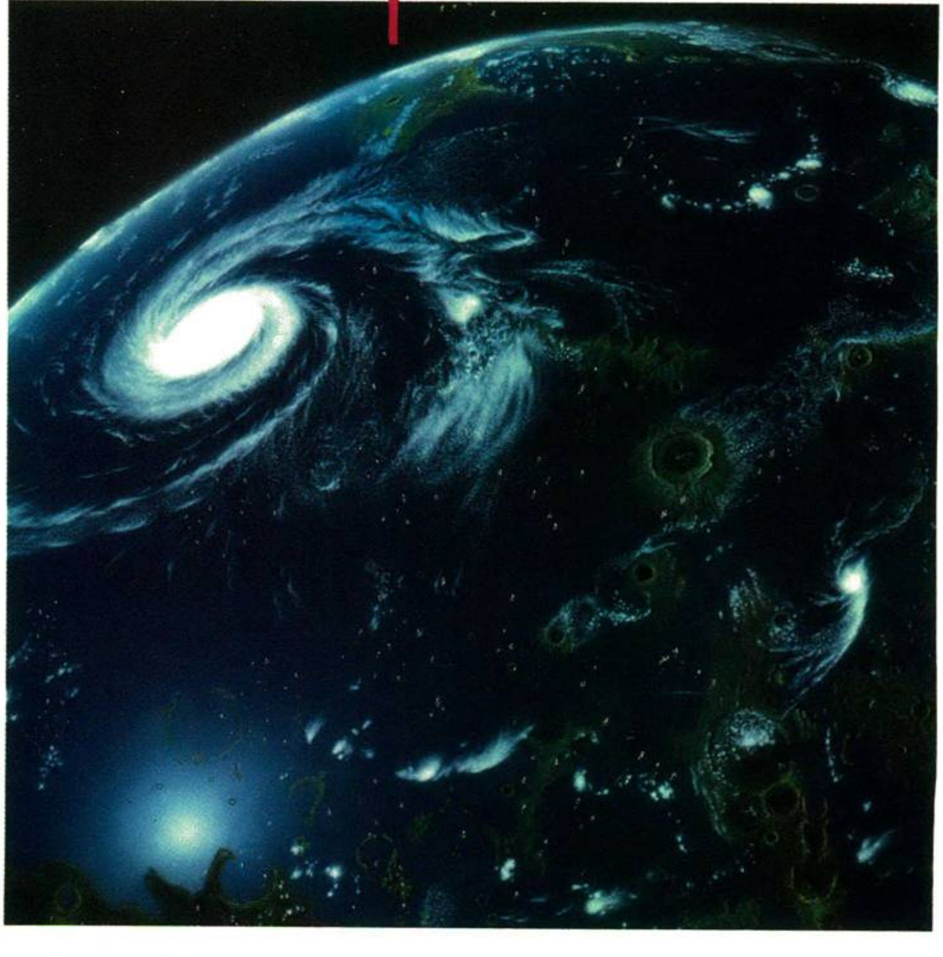
We pride ourselves on our intelligence and reason, which separate us from the other animals, though perhaps by less than we choose to think. Yet while it has made us, for now, the dominant species on the planet, there's no surety that our intelligence has survival value. Dinosaurs reigned supreme until a large asteroid struck 65 million years ago. In the chain of ecological catastrophes in its wake, life grew too difficult for dinosaurs and they perished. Yet how would we fare under similar conditions today? Could our technology cope?

Some space scientists have given serious thought to an idea called planetary engineering, or terraforming. This means taking one of the barren, hostile worlds of the solar system and altering its environment to permit life and perhaps human settlement. One example might be melting the Martian polar caps to release carbon dioxide and thicken the planet's atmosphere. This would provide greenhouse heating to warm the surface and raise the pressure to the point where liquid water could exist. Or, closer to home, we could give the Moon an atmosphere and hydrosphere, transforming it into a second, smaller Earth just next door. Another proposal would seed the clouds of Venus with organisms genetically engineered to reduce the massive carbon dioxide atmosphere and lower the surface temperature and pressure.

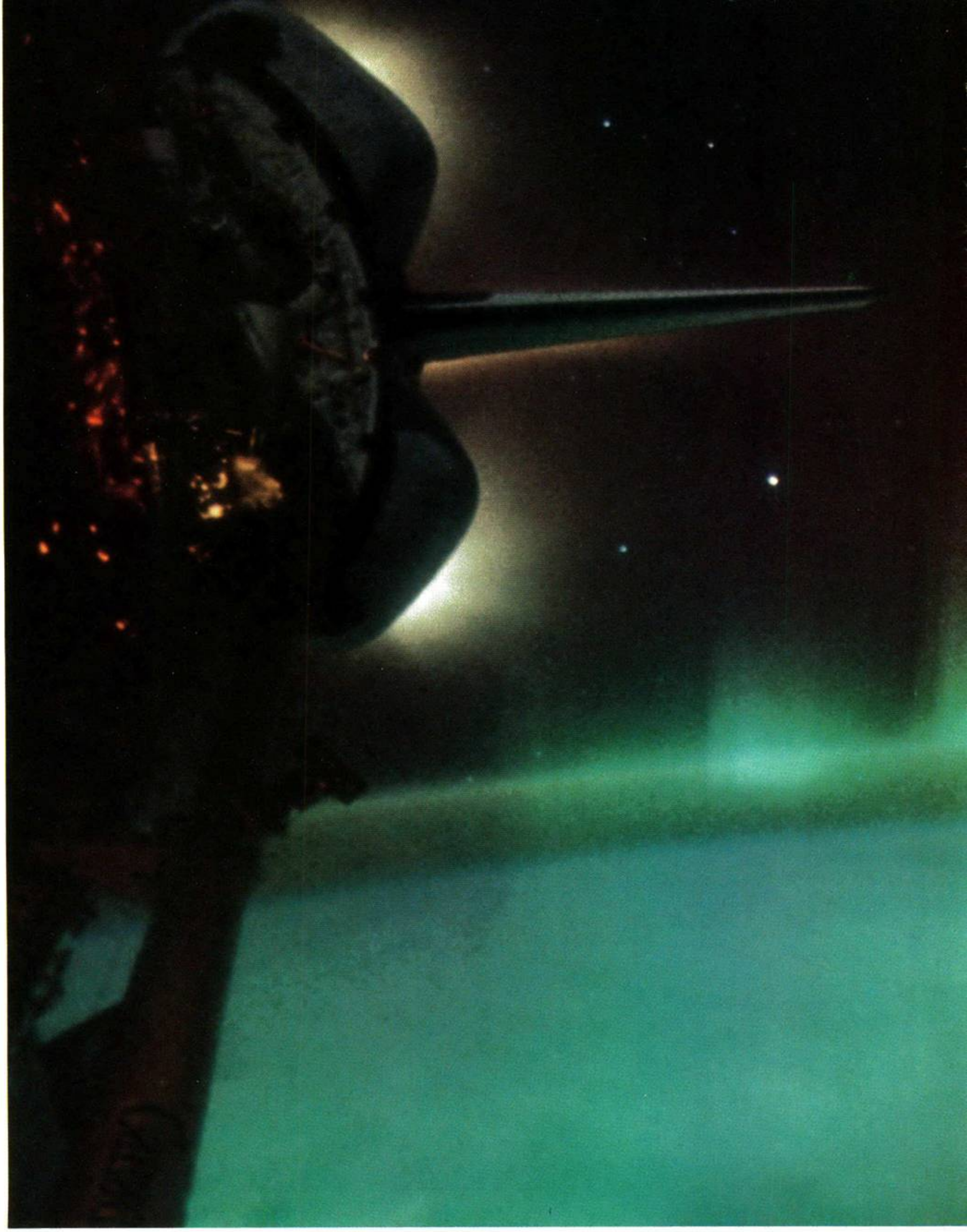
Some people are delighted by these scenarios, others horrified. Yet even if the plans never come to pass, it seems clear that should humans hold true to their heritage, we will continue to explore the worlds around us. Astronomy could be called the science of everything — and curiously, it's the only science that has so far escaped being linked to terrestrial woes. Perhaps this is true only because the one rule of the night sky seems to be "Look, but don't touch." For good or ill, this means that everyone sees the same universe and no one can stake a claim on it.

We walk outdoors on a cool, starlit night and look up into a beautiful universe about which we know so little. If we knew how to read it, nature's book could tell us all the secrets of the ages. Every day, astronomers and theorists decipher a couple more words or lines from the book, adding something to our knowledge. But there is so much to do and the nights are so few and so short. □

*__WE HAVE CHANGED EARTH'S__ environment largely by inadvertence, but what if we chose to alter another world? Could the Moon be made habitable with an atmosphere and hydrosphere? Will ocean waves break one day on the shores of lunar seas?*

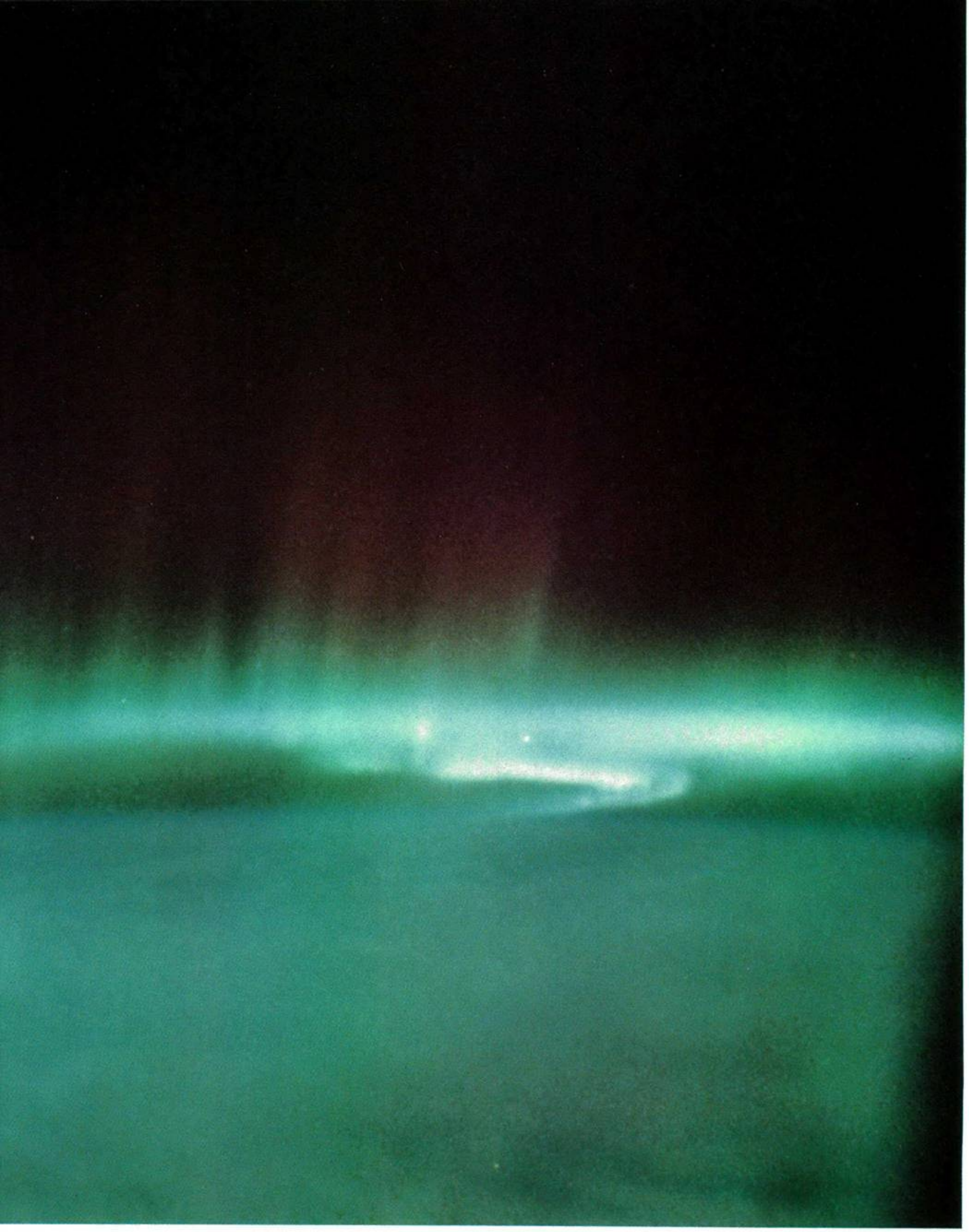


*__CURIOSITY AND A DRIVE TO UNDERSTAND__ the cosmos have characterized humanity for as long as we can tell. Our telescopes and space probes are simply the most recent steps in a journey that began many thousands of years before Stonehenge.*

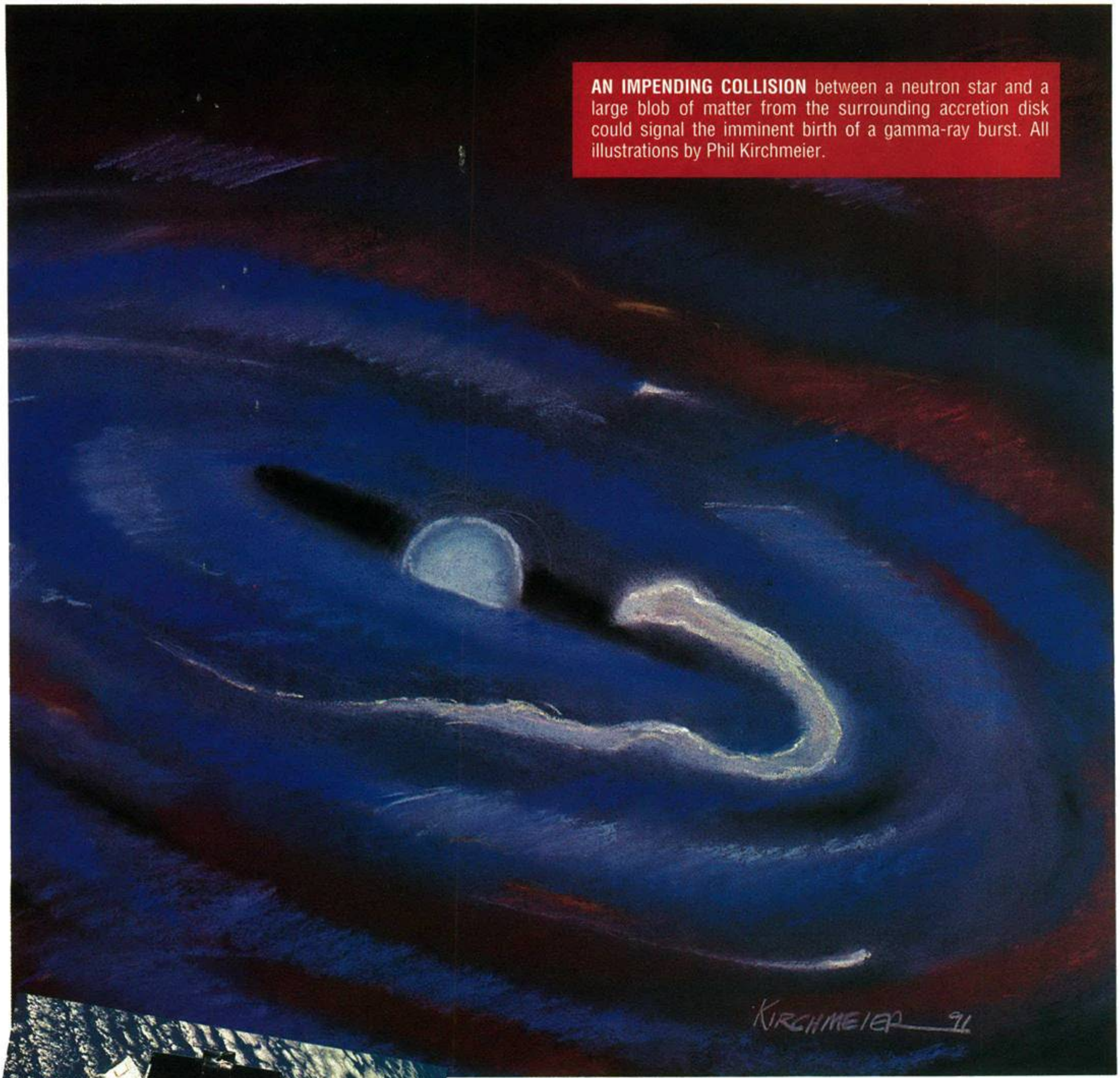


## Space Shuttle Shoots

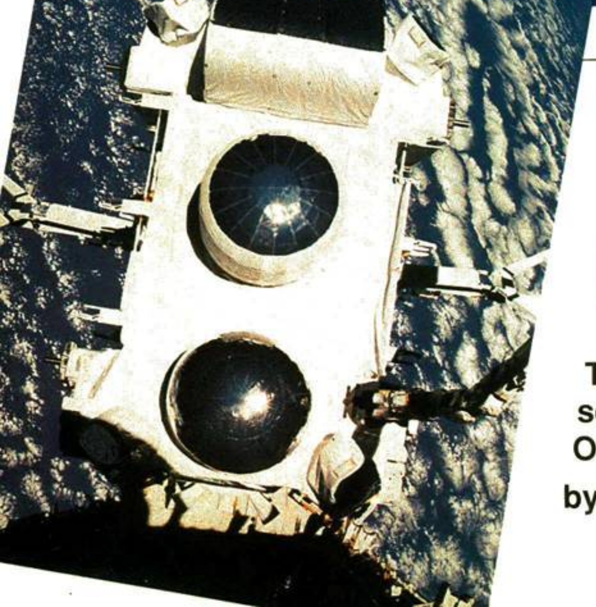
# AURORA



Look up! That's what most of us do when we want to view the wonders of the night sky. But that direction isn't always appropriate, especially if you're an astronaut in orbit around Earth. From space, some of the most spectacular nighttime views come when you look *down.* The astronauts on board the Space Shuttle Discovery found that out this spring during mission STS-39, when solar activity turned the upper atmosphere into a shimmering curtain of green and red auroral light. The colors seen in the aurora australis, or southern lights, arise from oxygen and nitrogen in our upper atmosphere, which give off these characteristic colors when excited by high-energy particles from the Sun. The white glow visible around Discovery's tail is from the orbiter's small maneuvering engines. NASA photo. — *Richard Talcott*



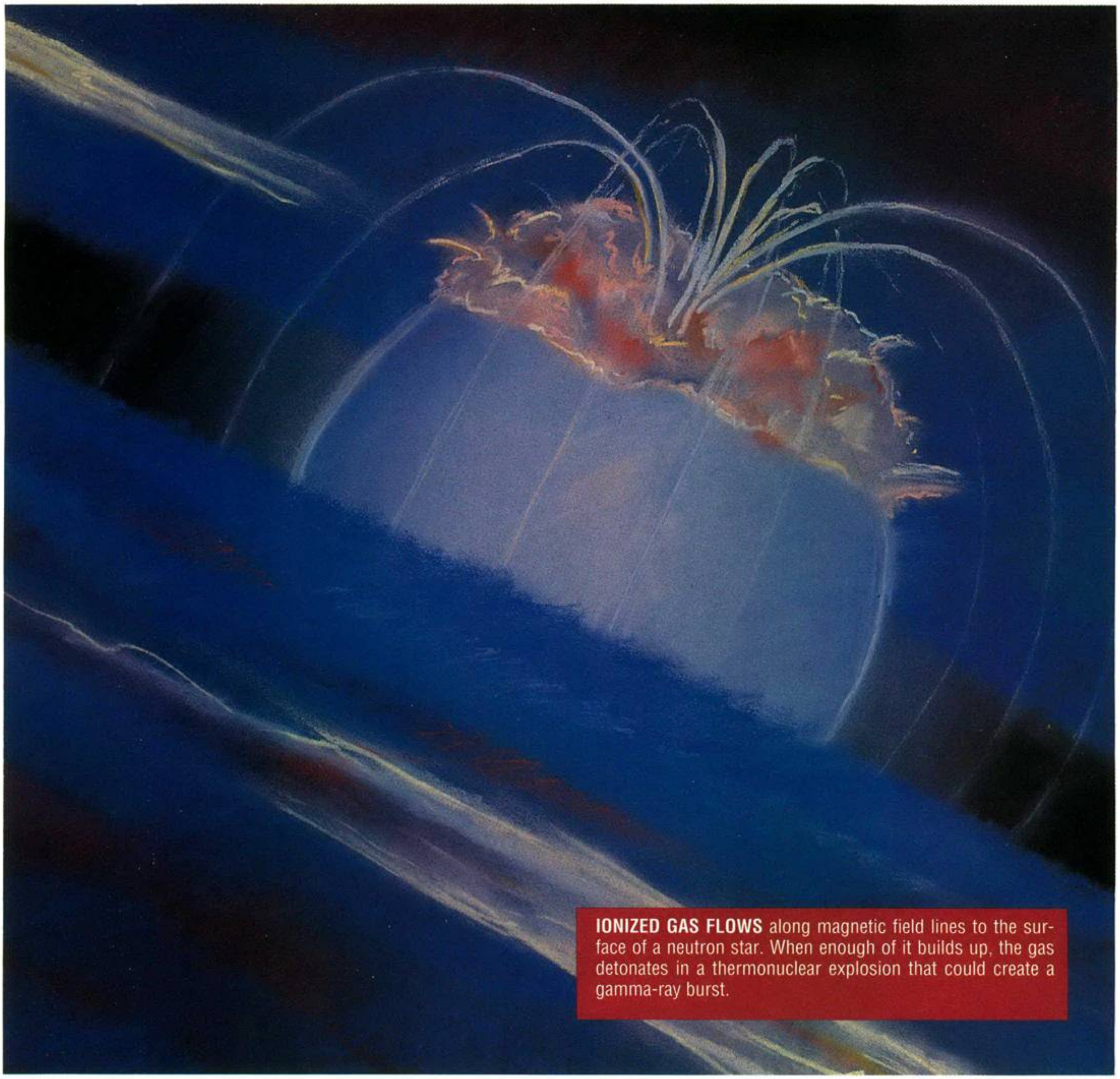
**AN IMPENDING COLLISION** between a neutron star and a large blob of matter from the surrounding accretion disk could signal the imminent birth of a gamma-ray burst. All illustrations by Phil Kirchmeier.



# A BURST OF GAMMA RAYS

**The enigmatic gamma-ray bursters may soon yield their secrets to the probing eye of NASA's Gamma Ray Observatory.**

**by Richard Talcott**



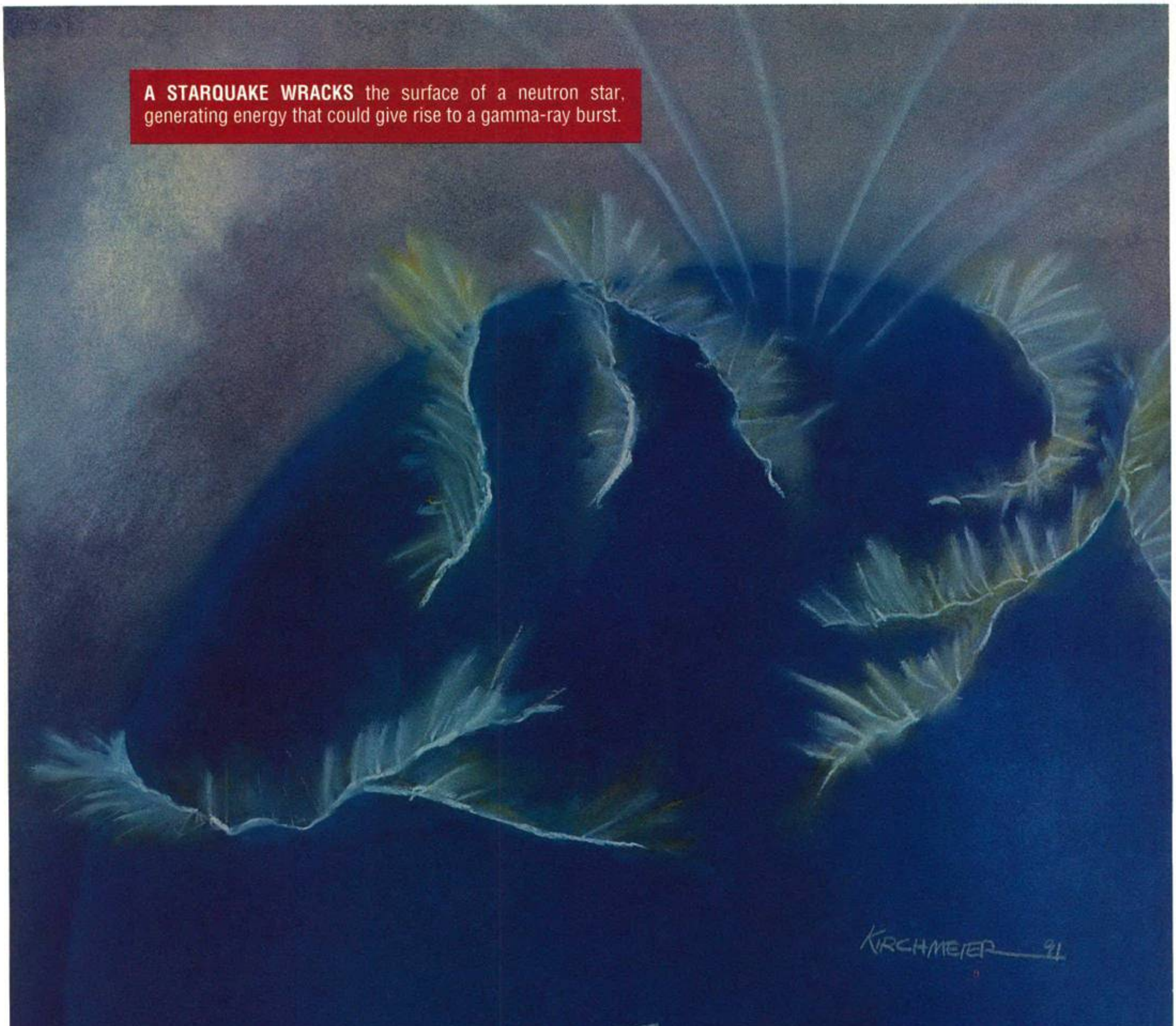
**IONIZED GAS FLOWS** along magnetic field lines to the surface of a neutron star. When enough of it builds up, the gas detonates in a thermonuclear explosion that could create a gamma-ray burst.

## ASTROPHYSICAL FRONTIERS

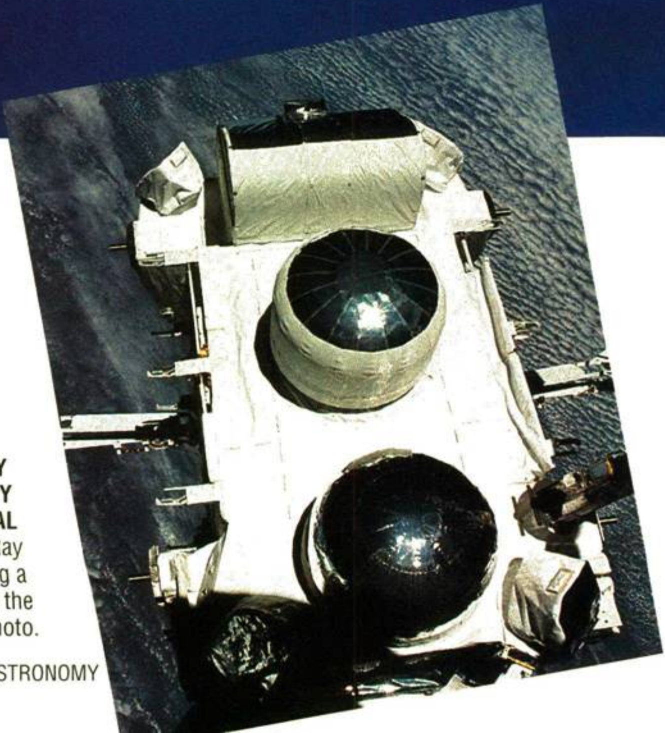
For nearly twenty years, gamma-ray bursters have baffled astronomers. These energetic objects release a flood of high-energy photons in a very short time, ranging from a fraction of a second to a few minutes. The bursts seem to occur at random and are seen only at gamma-ray energies. And with one notable exception, their positions on the sky don't coincide with any out-of-the-ordinary objects.

The same characteristics that make gamma-ray bursters so intriguing make it hard to unlock their secrets. Are they objects in our local neighborhood of the Galaxy, or do they reside in distant galaxies? Are they merely bright, or do they rival supernova explosions as among the most luminous objects in the universe? Are they caused by events at the surface of neutron stars, as most astronomers think, or is some unknown mechanism behind these intense outbursts? Despite twenty years of effort in trying to understand these mysterious objects, astronomers still aren't sure what they are, how far away they are, or what causes their extraordinary outbursts.

Now a new player has entered the field. With the launch of the Gamma Ray Observatory (GRO) last April, astronomers have the most sensitive and sophisticated experiment yet designed for studying gamma-ray bursters. The Burst and Transient Source Experiment (BATSE) on GRO consists of eight detectors that continuously search two-



**A STARQUAKE WRACKS** the surface of a neutron star, generating energy that could give rise to a gamma-ray burst.



**LAUNCHED TO STUDY HIGH-ENERGY ASTROPHYSICAL EVENTS,** the Gamma Ray Observatory is opening a new window on the universe. NASA photo.

thirds of the sky for gamma-ray bursts. During the first few months of the mission, GRO has witnessed nearly one gamma-ray burst per day (a total of 55 bursts in 70 days, as we go to press) — a rate nearly four times that of any other instrument flown to date. Mission scientists feel that if the observations continue to roll in as they have, answers to some of the many questions about gamma-ray bursters may start to emerge by the end of the year.

### A Serendipitous Discovery

As with many great astronomical

discoveries, gamma-ray bursters were discovered by accident. The first recorded burst came in 1967, when satellites in the Vela series detected a short, intense burst of gamma rays. (Most gamma rays, like most electromagnetic radiation with energies greater than visible light, cannot penetrate Earth's atmosphere.) The four Vela satellites in orbit at the time were not looking outward for astronomical purposes, however. Instead, they were pointing toward Earth, searching for the telltale emission of gamma rays that would signal a thermonuclear explosion in violation of the Nuclear Test Ban Treaty.

The Vela satellites recorded more than a dozen gamma-ray bursts over a three-year period. By timing when a given burst reached the different satellites, the researchers could calculate roughly where the burst came from. They learned that the bursts weren't coming from Earth, nor did they originate on the Sun, Moon, or planets. The bursts clearly came from outside the solar system, but exactly where remained a mystery.

Because the observations were made under the auspices of the military, the results weren't immediately made public. Not until 1973 did the news of gamma-ray bursters first hit the astronomical press. When it did, astronomers rushed to build new detectors that would fly on Earth-orbiting satellites and planetary probes. The general consensus then was that once the positions of these objects were known to within a couple of arcminutes, finding the optical counterparts would be fairly easy.

But that has not happened. Out of the several hundred gamma-ray bursters discovered so far, nearly 200 have good positions. But when astronomers examine those positions with powerful optical telescopes, they see nothing unusual, just a collection of faint, ordinary-looking stars and galaxies.

### A Neutron Star Link?

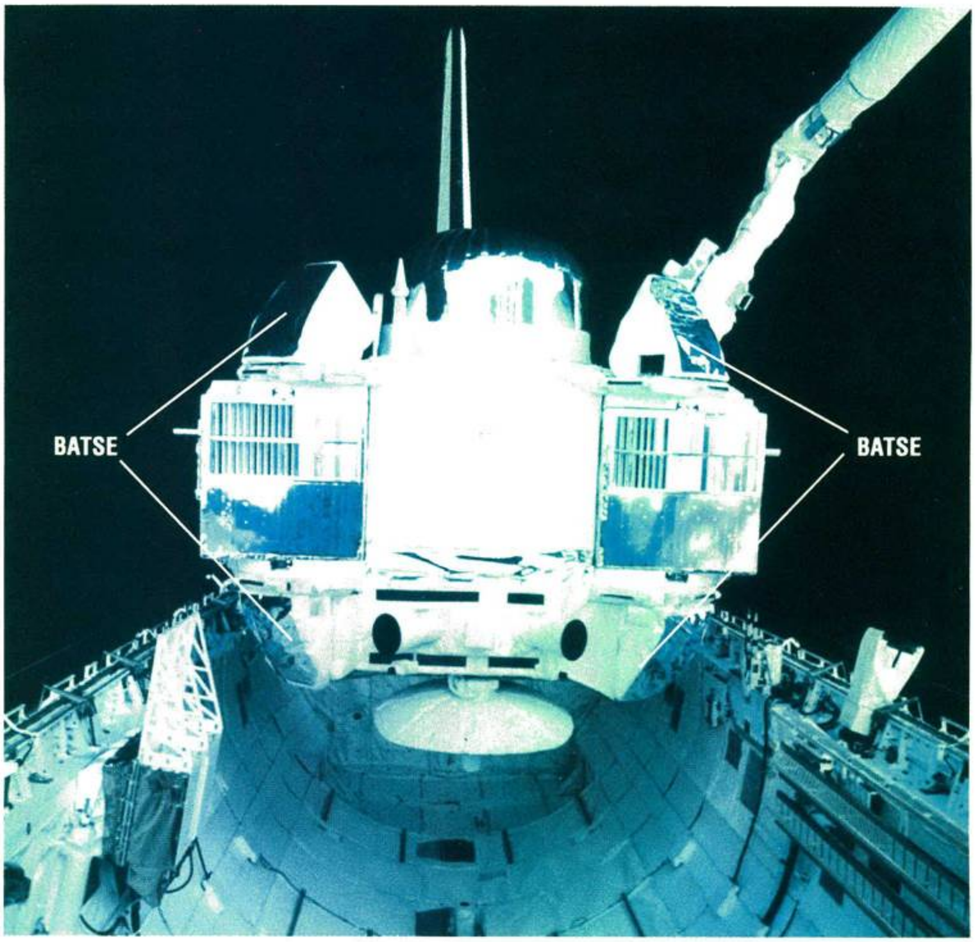
There is only one case where an accurate position for a gamma-ray burster coincides with an interesting object. That's the case of the intense burst recorded on March 5, 1979. Nine separate spacecraft observed this event, which at the time was the most energetic gamma-ray burst ever seen. After astronomers analyzed the burst's arrival time at each spacecraft, they were able to pin down its location more precisely than that of any other gamma-ray burst. And smack in the middle of this area is the supernova remnant N49 in the Large Magellanic Cloud.

What better place is there to find a neutron star than in a supernova remnant? But the unusual behavior of this burst — it varied in intensity with an 8-second period — and the fact that the source is one of only a few that has burst forth more than once may mean this is not a typical gamma-ray burster.

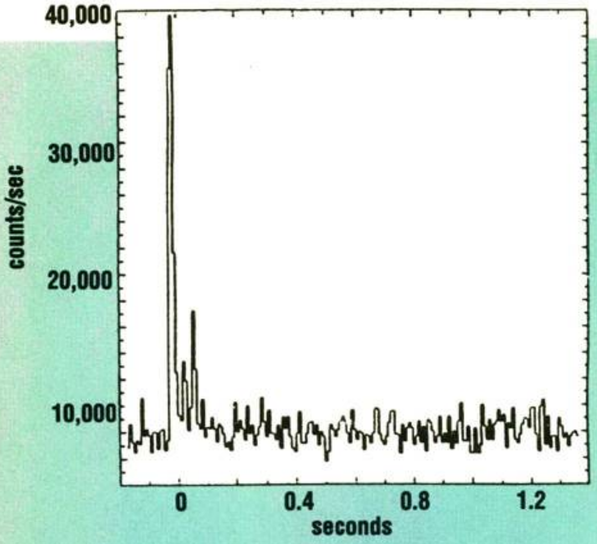
Some astronomers even doubt the identification of this burst with the supernova remnant and believe instead that the burst arose in a foreground object along the same line of sight. They point out that such a bright burst in the Large Magellanic Cloud — 170,000 light-years away — would, for a fraction of a second, have to be as bright in gamma rays as our entire Galaxy is at all wavelengths.

Although astronomers have advanced dozens of theories over the years to explain gamma-ray bursters, today all the major theories involve neutron stars. A neutron star is the end product of stellar evolution for stars substantially more massive than the Sun. A massive star spends most of its life quietly burning hydrogen into helium, just as the Sun does. After the hydrogen in the star's core is exhausted, the star relies on helium and then progressively heavier elements to provide energy. Eventually, the star's core is made of iron. Because fusing iron *consumes* energy rather than generates it, the core can no longer support itself against gravitational collapse. The core implodes, a shock wave forms that rips apart the outer layers of the star, and a supernova is born.

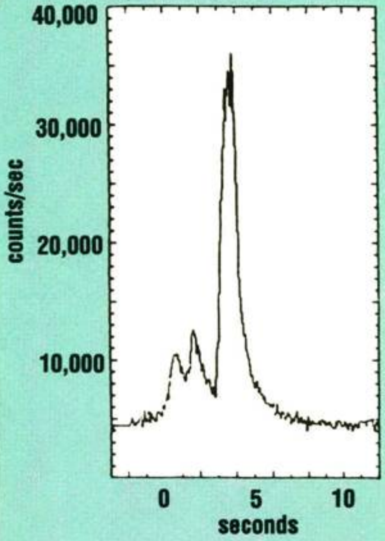
The inner part of the star collapses until it reaches the density of nuclear matter. What's left is a neutron star — an object with slightly more mass than the Sun squeezed into a sphere only 10 kilometers across. Because of its enormous density, it has an incredibly strong gravitational field near its surface. The collapse of the star also compresses the magnetic field until it is a trillion times stronger than before the collapse.



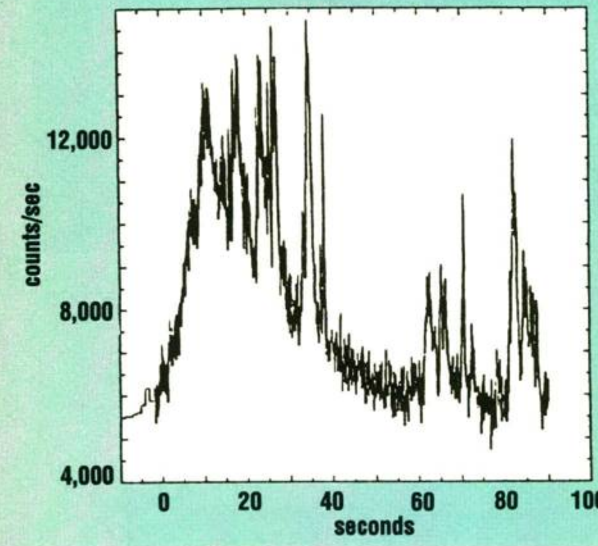
**DETECTING ENERGETIC BURSTS** of gamma rays is the objective of the BATSE detectors on the Gamma Ray Observatory. NASA photo.



**NO TWO GAMMA-RAY BURSTS** ever look the same. Here is an extremely energetic burst that lasted for just a few milliseconds.



**A FIVE-SECOND BURST** reaches the same peak intensity as the burst above, but the total energy emitted in those 5 seconds dwarfs that of the first burst.



**VASTLY MORE COMPLEX** is this 100-second burst, which shows several nearly equal peaks in intensity at much lower energies than the bursts above. All data on this page courtesy Gerald Fishman.

### Possibilities Galore

These two attributes — a strong gravitational field and an intense magnetic field — are what make neutron stars attractive as sources for gamma-ray bursters. There are several theories that explain how a neutron star could give rise to a gamma-ray burst. What follows are just a few of them.

One idea has thermonuclear explosions occurring on the surface of the neutron star. For this to happen, the neutron star has to be part of a binary system. The neutron star's strong gravity slowly pulls ionized gas from its companion, which gets funneled by the strong magnetic field onto the magnetic poles of the neutron star.

Over a long period of time, the material builds up on the star's surface. Eventually, the density, pressure, and temperature of the material become high enough that fusion begins. The hydrogen fuses slowly, but the helium resulting from these nuclear reactions fuses explosively, giving rise to the gamma-ray burst. It would be only fitting if gamma-ray bursts, which were discovered by satellites searching for nuclear explosions on Earth, turned out to be caused by nuclear explosions on stars.

Another possibility is that a large chunk of matter could fall on a neutron star. The source of the chunk could be a big blob of material in an accretion disk surrounding the neutron star, or something as esoteric as an asteroid or comet falling onto the neutron star. In either case, as the matter approaches the star, it is accelerated to a significant fraction of the speed of light. The high-speed collision that follows generates the burst of gamma rays.

A third possibility is that the gamma-ray bursts arise from neutron starquakes. In this scenario, the crust of the neutron star becomes unstable — perhaps incoming material adds too much weight to the crust — and it violently readjusts itself. The energy from this "starquake" then powers the gamma-ray burst.

From what we know now, any of these theories could be right. In fact, more than one could be right. No two gamma-ray bursts appear the same. Some last only a few milliseconds and others last a couple of minutes; some rise to a maximum very smoothly and then drop off smoothly while others show much more structure.

The early results from GRO show a wide variety of gamma-ray bursts (see left); that several processes may create them is certainly possible. That's what Gerald Fishman, principal investigator for BATSE, believes. He likens the situation to what the users of the first optical telescopes faced with the discovery of nebulae. To their early instruments, all the nebulae looked alike. But we now know that only a few were real nebulae; most were galaxies and star clusters masquerading as nebulae.

Though the causes of gamma-ray bursts may remain mysterious for a while, the puzzle of where the gamma-ray bursters reside could be solved quickly. Fishman thinks that GRO will have enough observations by the end of this year to tell whether the bursts come predominantly from the plane of the Milky Way, which would argue that they belong to our Galaxy, or whether they are randomly distributed in space and thus must inhabit the far reaches of the universe.

GRO certainly won't solve all the mysteries surrounding gamma-ray bursters. But by detecting nearly one gamma-ray burst a day, the observatory will give astronomers enough information to eliminate some theories and gain more confidence in others. That's the way science works: take a few observations, develop a hypothesis, test the hypothesis with further observations, modify the hypothesis, and keep on going until you reach a consistent physical picture. Within the next few months, the Gamma Ray Observatory may move astronomers one step closer to a clear picture of gamma-ray bursters. ☐

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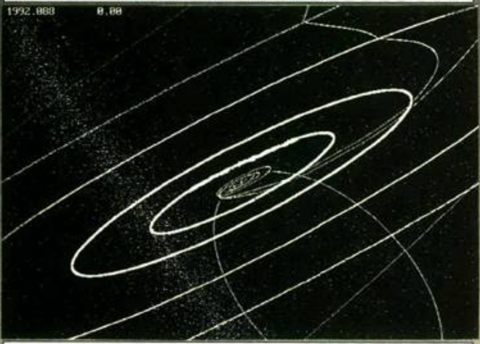

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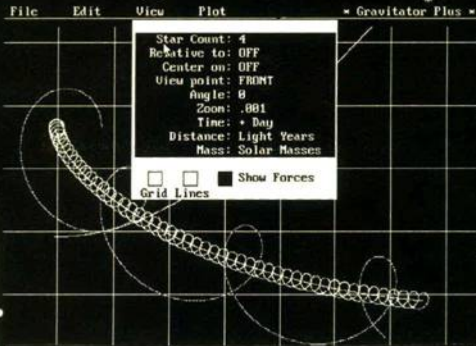

```
Star Count: 4
Relative to: OFF
Center on: OFF
View point: FRONT
Angle: 0
Zoom: .001
Time: • Day
Distance: Light Years
Mass: Solar Masses
```

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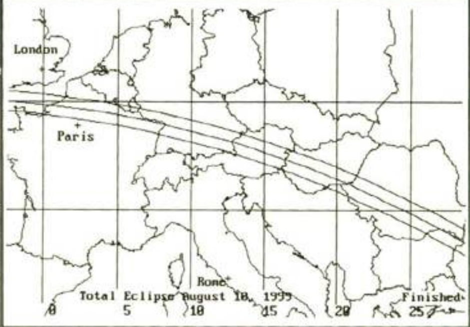

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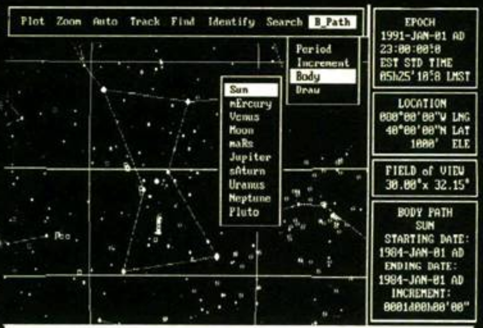

```
EPOCH
1991-JAN-01 AD
23:00:00.0
EST STD TIME
05h25'10.8 LMST

LOCATION
000°00'00"W LNG
40°00'00"N LAT
1000'  ELE

FIELD of VIEW
30.00°x 32.15°

BODY PATH
SUN
STARTING DATE:
1984-JAN-01 AD
ENDING DATE:
1984-JAN-01 AD
INCREMENT:
0001d00h00'00"
```

```
Partial Solar Eclipse
Magnitude: 0.170  Obscuration:  0.3%
LAST CONTACT
```

```
(***   NGC 3034  Located at TARGET   ***)

NGC# ObjTyp Cst  Mag Type          Size   R
3034 Galaxy UMA  9.5 dm            11'x 5'

(CIRCUMPOLAR)   TT: 17h35'28.3   (CIRCUMPOLAR)
```

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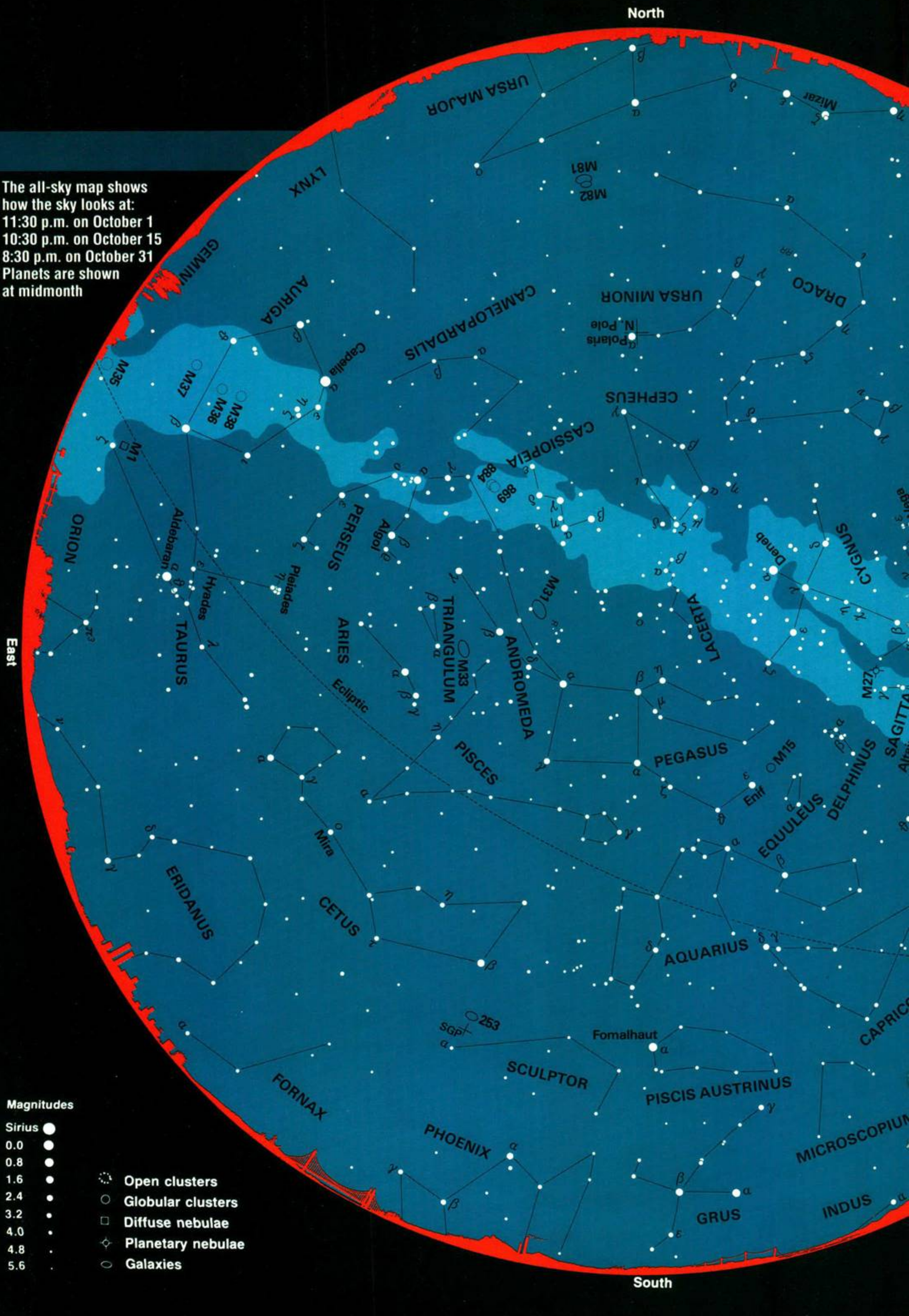
10:30 p.m. on October 15
8:30 p.m. on October 31
Planets are shown at midmonth


North
South
East
URSA MAJOR
Mizar
M81
M82
LYNX
GEMINI
AURIGA
CAMELOPARDALIS
URSA MINOR
N. Pole
Polaris
DRACO
CEPHEUS
Capella
M35
M37
M36
M38
M1
CASSIOPEIA
884
869
PERSEUS
Algol
ORION
Aldebaran
Hyades
Pleiades
TAURUS
CYGNUS
Deneb
Vega
M31
LACERTA
TRIANGULUM
M33
ARIES
ANDROMEDA
Ecliptic
M27
SAGITTA
Altair
PISCES
PEGASUS
M15
Enif
EQUULEUS
DELPHINUS
Mira
ERIDANUS
CETUS
AQUARIUS
SGP
253
Fomalhaut
SCULPTOR
PISCIS AUSTRINUS
CAPRICORNUS
FORNAX
PHOENIX
MICROSCOPIUM
GRUS
INDUS
Magnitudes
Sirius
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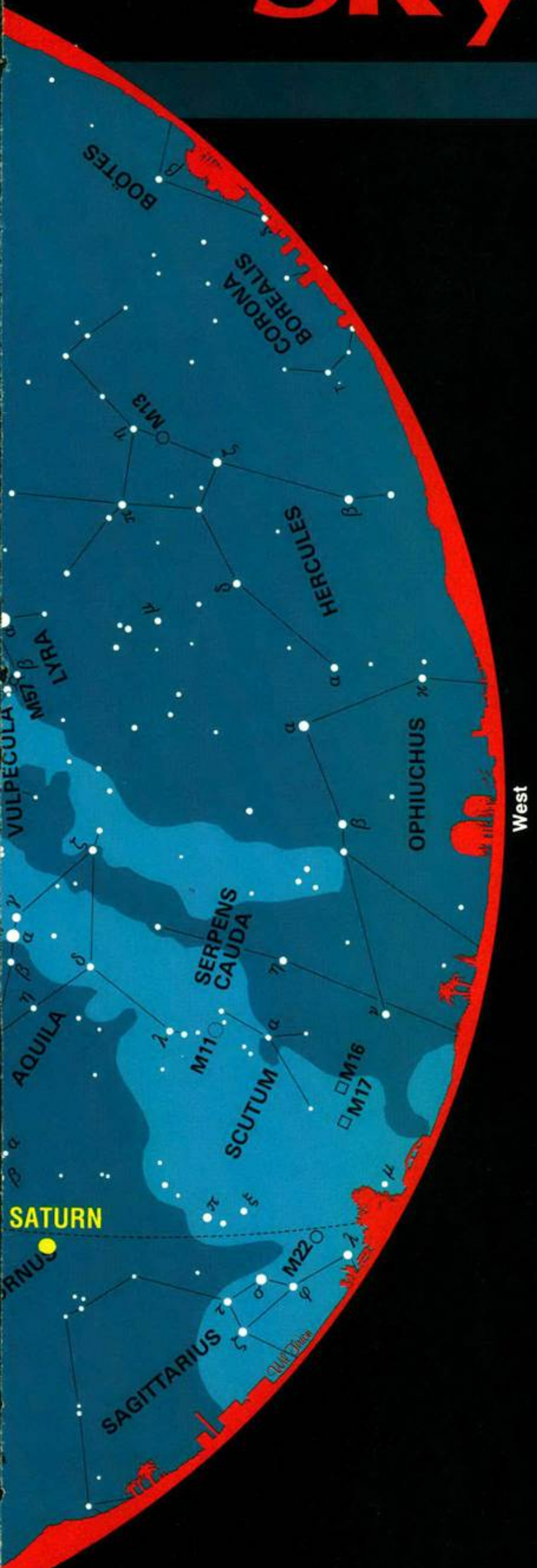
Open clusters
Globular clusters
Diffuse nebulae
Planetary nebulae
Galaxies

# Sky Almanac



## October 1991

### A DAZZLING DUO

For the second time in four months, the two brightest planets pass close to one another. This time, however, Venus and Jupiter command the morning sky. The two planets are prominent throughout October, but they are particularly noticeable around midmonth when they lie just 2° apart.

### VENUS OCCULTED ON OCTOBER 4

Venus sees a lot of action this month. Not only does it pass near Jupiter in mid-October, but also it is occulted by the waning crescent Moon on the morning of October 4. The best view of the event comes from Hawaii, where Venus reappears before daybreak, but observers in parts of Mexico and South America can see the entire event during daylight hours.

### ORIONIDS PEAK ON OCTOBER 22

Although the nearly Full Moon hampers viewing of the Orionid meteor shower at its peak on the morning of October 22, you can still catch 10 to 15 of the swiftly moving meteors in the hour before dawn on October 21.

### SATURN ALONE IN THE EVENING

Almost all of the planetary action has moved to the morning sky this autumn, leaving Saturn as the lone bright planet in the evening sky. Still, the ringed planet more than holds its own, shining brightly at magnitude 0.5 among the background stars of Capricornus and offering stunning views to telescope owners.

## Calendar of Events

**2** The Moon is at perigee (229,546 miles from Earth), 2:02 p.m. EDT

**3** Mercury is in superior conjunction

**4** Venus is occulted by the Moon, 11 a.m. EDT

Saturn is stationary

**5** The Moon passes 5° south of Jupiter, 1 a.m. EDT

Mars passes 3° north of Spica, 8 p.m. EDT

**7** New Moon is at 5:39 p.m. EDT

**8** Venus passes 3° south of Regulus, midnight EDT

**9** Draconid meteor shower peaks

**15** The Moon is at apogee (251,135 miles from Earth), 7:02 a.m. EDT

First Quarter Moon is at 1:33 p.m. EDT

**16** The Moon passes 2° north of Saturn, 8 a.m. EDT

Venus passes 2° south of Jupiter, 11 p.m. EDT

**22** Orionid meteor shower peaks

**23** Full Moon is at 7:08 a.m. EDT

**27** The Moon is at perigee (228,912 miles from Earth), 10:42 a.m. EST

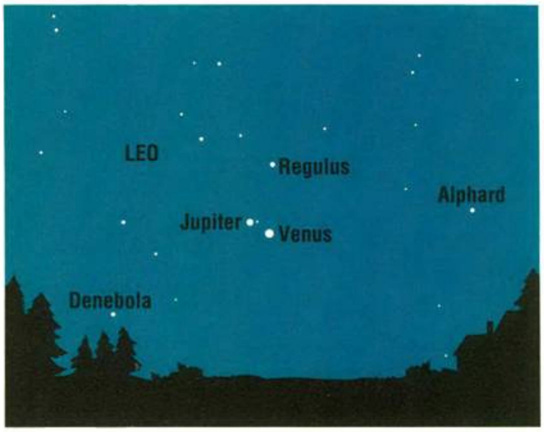
**30** Last Quarter Moon is at 2:10 a.m. EST

## VENUS AND JUPITER TOGETHER, AGAIN

As October begins, the two brightest planets lie in the east before dawn. Venus and Jupiter can't be mistaken for stars. They're both far brighter than any stars, plus they shine with a steadier light. They're a lovely sight near each other, bright beacons in the predawn twilight.

A fainter object — even though it's one of the sky's brighter stars — is located near the planets. This is Regulus, "the heart of the Lion" in the constellation Leo. Regulus is destined to be Jupiter's companion for much of the coming year. All three of these objects are bright and very noticeable, but Venus is by far the brightest at magnitude –4.5. Jupiter comes next at magnitude –1.8, and Regulus is the dimmest, shining at magnitude 1.4.

As you watch the three objects during October, you will see first Regulus and then Jupiter sweep past Venus as they climb higher in the predawn sky. Regulus lies 4° north of Venus on October 7/8, while Jupiter lies 2° north of Venus on October 16/17. But the most spectacular view comes on the mornings around October 4, when the waning crescent Moon sweeps past the trio. The Moon passes particularly close to Venus before dawn on the 4th, occulting the planet as seen from Hawaii. (See Through the Eyepiece for more information on observing this occultation.)



**VENUS AND JUPITER DOMINATE** the eastern predawn sky throughout October, though they are most conspicuous around the 16th when they lie just 2° apart (above). Stewart Lollar photographed the two planets (Venus at far right; Jupiter to its left) in June's evening sky, when they were joined by the Moon and Mars.

## METEORS FROM THE HUNTER

You'll have to pick your viewing time for this year's Orionid meteor shower carefully. That's because the shower peaks on the morning of October 22, when the Moon is just one day away from being full. In fact, your best bet for seeing the shower is not on that morning — the nearly Full Moon doesn't set until after morning twilight begins and overwhelms nearly all the meteors. Instead, watch for the shower on the morning of October 21. Then the Moon sets about an hour before the onset of morning twilight, giving you a brief "dark sky" window for meteor observing.

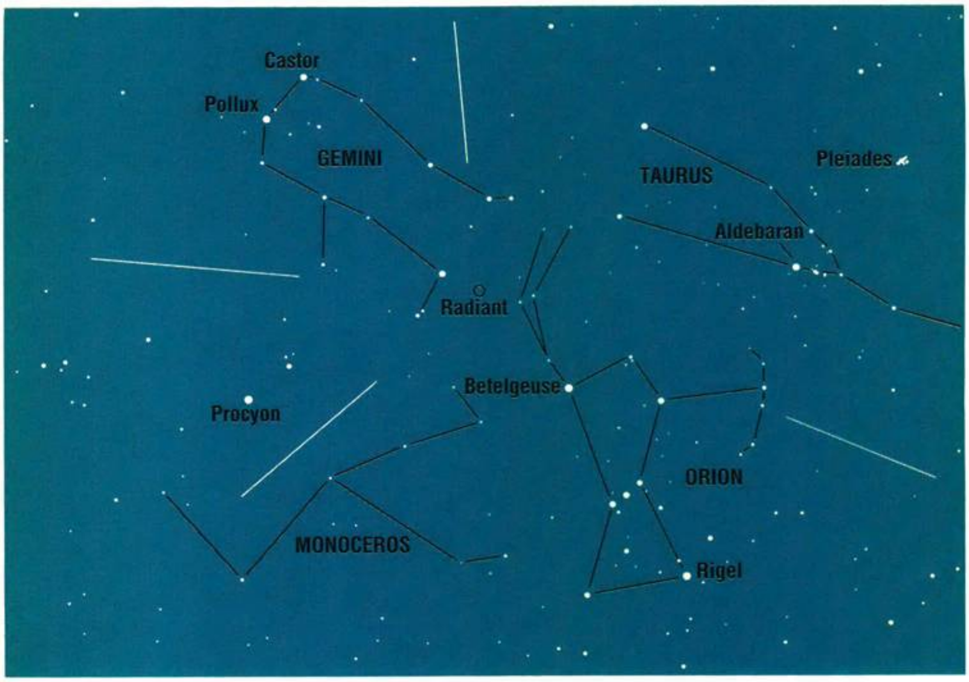
Fortunately, the Orionids are a reliable shower. The shower typically produces a couple of dozen meteors per hour at its peak. Unfortunately, thanks to the bright moonlight this year, you'll have to be content with seeing perhaps 10 to 15 meteors in the hour before dawn on the 21st. Find a wide-open, rural site to view the shower from — city lights wash out fainter meteors as effectively as the Moon does.

## SEEK THE FALSE DAWN

Where city lights are scarce, the zodiacal light — or false dawn — towers above the eastern horizon before sunrise this month. This tall pyramid of faintly glowing light becomes visible about an hour before the onset of true dawn. To see it, you must be looking from under a very dark country sky.

Like the Sun, Moon, and planets, the zodiacal light belongs to the flat plane of the solar system. The Moon and planets shine with reflected sunlight.

So do tiny grains of dust in the solar system's plane — the source of the zodiacal light. The light is easier to see on autumn mornings than at other times of the year because the ecliptic then makes a steep angle to the eastern horizon. A good view of this ghostly apparition, in the darkest hour before dawn, can be spellbinding!



**CATCH THE ORIONID METEOR SHOWER** in the hour before dawn on October 21 or risk missing it altogether — the nearly Full Moon washes out the peak of the shower on the 22nd. Expect to see 10 to 15 meteors radiating from near Orion's upraised arm during the prime observing hour.

## *OCTOBER'S PLANETS*

The only bright planet now visible in the evening sky is Saturn. You can find it low in the south when night begins. Earth's spin beneath the sky makes Saturn appear to move westward as the night passes, and it drops below the horizon around midnight. The ringed planet is slightly fainter now, at magnitude 0.5, than it was during the summer.

Saturn remains in western Capricornus all month. It has been moving westward, or retrograding, in front of that constellation's background stars since May. That comes to an end on October 4/5, however, when Saturn is stationary. Afterward, it begins moving eastward in front of the stars again. The retrograde motion of an outer planet is an illusion that occurs whenever Earth passes between that planet and the Sun. The end of retrograde motion for Saturn is a sign that we are now far ahead of the planet in our smaller and faster orbit around the Sun. Saturn will grow fainter and be in our sky for fewer hours of the night during the months ahead.

Venus creeps over the eastern horizon nearly four hours before the Sun comes up. It stands well up in the east before dawn, dazzlingly bright at magnitude –4.5. Venus is the brightest of three objects that cluster together before dawn in October. The other two objects, the planet Jupiter and the bright star Regulus, lie below Venus when the month begins. They both pass Venus in the course of this month, to be higher than it in the east before dawn when October ends.

Jupiter also rises nearly four hours before the Sun in October. At magnitude –1.8, it is the second-brightest starlike object in the sky after Venus. Jupiter has only recently returned to the morning sky after passing behind the Sun. It lies in the constellation Leo, near the star Regulus, and it will stay in Leo until it goes behind the Sun again early next fall. Jupiter will be getting brighter, and staying in our sky longer each night, in the coming months. It comes to opposition in late February.

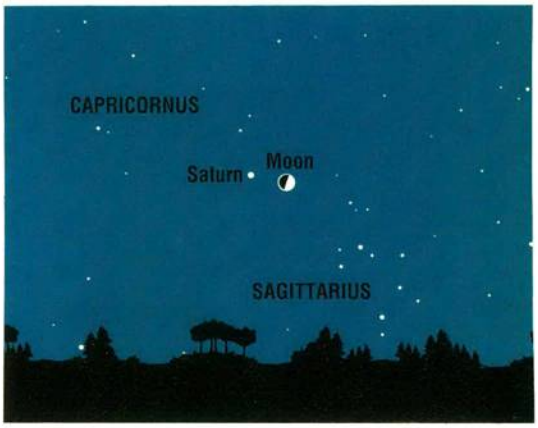
After Saturn, Venus, and Jupiter, the planet pickings this month are pretty slim. Mercury passes behind the Sun, a configuration known as superior conjunction, on October 3. It comes into view very low in the west-southwest at the end of October, but it won't be very easy to see. On the 31st, it lies just 1° above the horizon 30 minutes after sunset. The peak of this rather poor evening apparition is in mid-November.

As with Mercury, Mars can't be seen this month either. It's also traveling behind the Sun as seen from Earth and will be in conjunction with the Sun next month.

## *THE STARRY SKY*

One of the first constellations taught to children is Cassiopeia the

**ENJOY SATURN** on these long October evenings — it's the only bright planet remaining in the evening sky. And don't miss the pretty pair formed by Saturn and the First Quarter Moon on the evening of October 15.



Queen. Cassiopeia's five brightest stars form the shape of the letter M or W, depending on the time of year and the time of night you view the constellation. This month, you'll find the W of Cassiopeia ascending in the northeast in the evening hours. The constellation's brightest stars shine between 2nd and 3rd magnitude and they form a compact group, a combination that never fails to draw the eye.

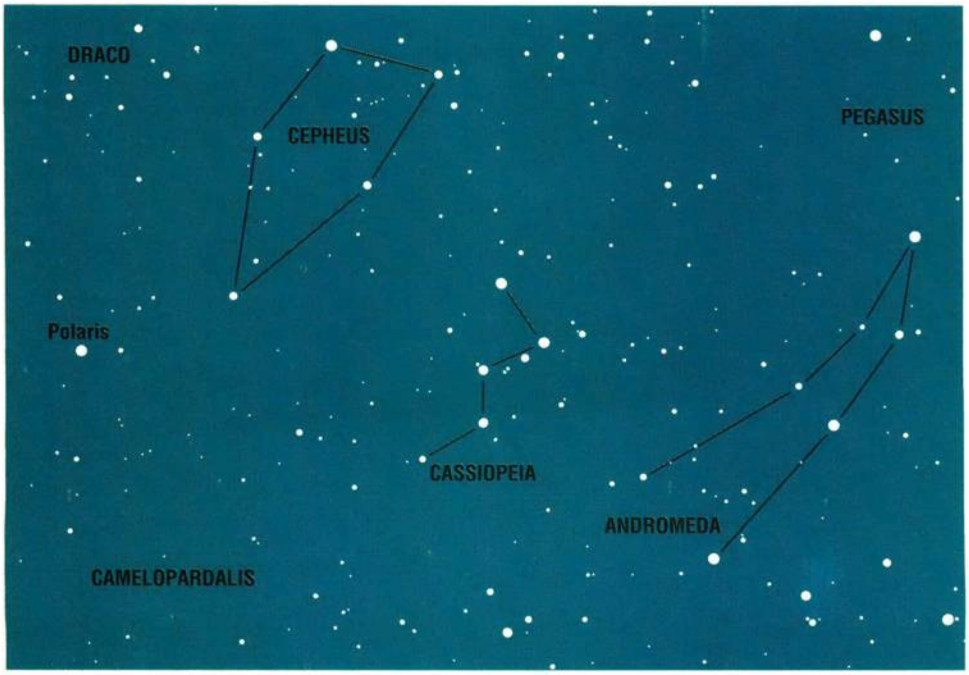
In Greek mythology, Cassiopeia was a queen of Ethiopia. She was said to be beautiful, but vain. She angered the sea nymphs by boasting that her own beauty was greater than theirs. They appealed to the god of the sea, mighty Neptune, who responded by sending a sea monster or great whale — known to us as Cetus — to ravage the coast of Ethiopia.

Cassiopeia's husband, King Cepheus, appealed to the other gods. They told him that he could only rid his country of the monster by sacrificing his young daughter, Princess Andromeda. The parents were heartsick, but they reluctantly chained Andromeda to a rock by the sea. As the monster loomed near her, a winged figure appeared in the sky. It was the flying horse Pegasus, ridden by a young hero named Perseus. He had recently slain the Medusa, a dreadful creature with snakes instead of hair, whose gaze turned all living creatures to stone.

Luckily, Perseus happened to have Medusa's head, which he'd recently chopped off, in a bag. He pulled the head from the bag, showed it to Cetus, and the monster turned to stone. He and the princess were married, naturally, and the gods were so pleased that they transported the Queen, the King, the Princess, the Hero, the Flying Horse, and the Whale to the heavens.

Cassiopeia is a circumpolar constellation as seen from the northern United States. That means it remains above the horizon at all times. While you're looking at Cassiopeia, also locate Ursa Major, which contains the famous Big Dipper asterism. If you draw a straight line from the Dipper through the pole star and beyond, you'll come to Cassiopeia. Like hands on a broken clock, the Big Dipper and Cassiopeia wheel in a counterclockwise direction around the heavens every 24 hours. They are always opposite each other in the sky, so you can always use one to find the other.

**CASSIOPEIA THE QUEEN** shines regally in the northeast on October evenings. Look for a prominent, W-shaped group of stars about halfway up on the dome of the sky.



Cassiopeia has another unique distinction. If you were to travel to the star system nearest our Sun — the Alpha Centauri system — and look at the sky from there, nearly all our familiar constellations would appear unchanged. In contrast to the vast size of the Milky Way Galaxy, the short hop to Alpha Centauri wouldn't alter our perspective all that much. But you'd find one constellation that appeared markedly different. If you looked back in the direction of our solar system, you'd see our Sun as a bright, extra star among the other familiar stars of Cassiopeia. □

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*Deborah Byrd is the creator of "Star Date," an independently syndicated daily radio series on commercial and public radio.*

# Through the Eyepiece *by* Rick Shaffer

## *VENUS DOMINATES THE MORNING SKY*

There's no mistaking Venus in the predawn sky this month. The brilliant planet moved into the morning sky at the end of August and reached greatest brilliancy at the end of September. Now, as October begins, Venus remains incredibly bright at magnitude –4.6 and is high in the east before dawn. By the second half of the month, Venus has faded only slightly and rises nearly four hours before the Sun, which gives you plenty of time to scrutinize it before twilight begins.

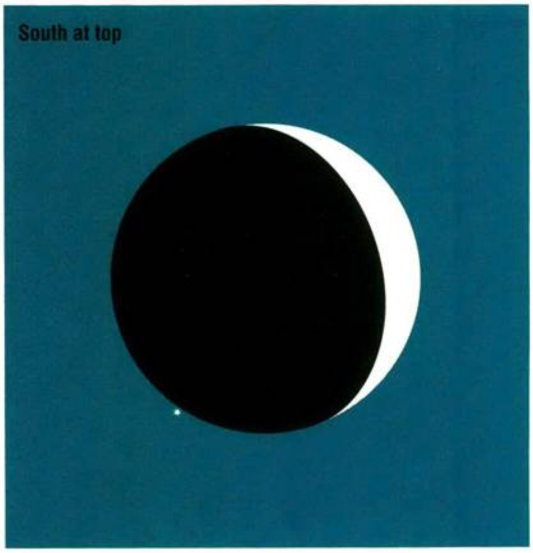
Even so, your best view of Venus through a telescope will likely come as the sky brightens during morning twilight. By then the seeing should be at its best, both because Earth has lost as much heat as it's going to for the night, which makes our atmosphere more steady, and because Venus is higher in the sky, where the seeing is usually better.

In fact, there's nothing that says you can't observe Venus *after* the Sun rises. It is certainly bright enough to see in daylight, even through a small telescope, and the sight of the white planet against the blue sky is impressive.

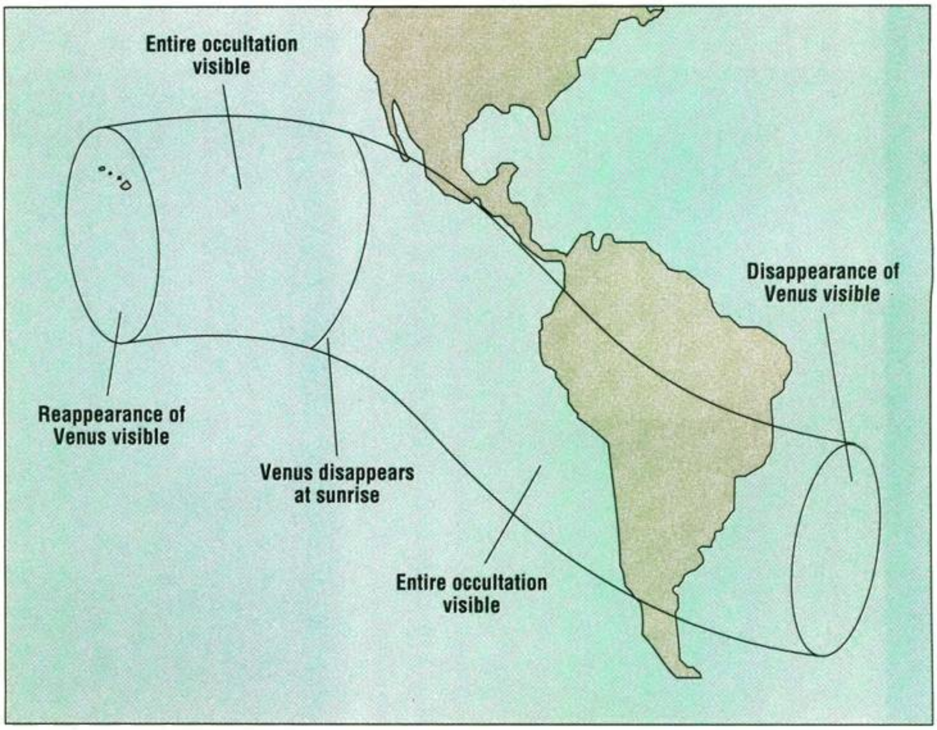
What will you see as you look at Venus? At the beginning of October, Venus presents a large disk measuring 37" across that is only 29-percent lit. Venus' apparent size shrinks rapidly during the month, while the planet's crescent phase waxes considerably. By the end of the month, Venus appears 25" across and has a 49-percent-lit phase.

If you're going to pick one morning this month to observe Venus, make it the morning of the 4th. In a virtual reprise of the July 11 solar eclipse, the Moon that day eclipses Venus for observers in Hawaii, much of the eastern Pacific, the west coast of Mexico, and central South America. Lest my play-on-words confuses you, this event is normally called an occultation and not an eclipse, though it really is the same phenomenon.

Observers in Hawaii will have the best view of this event. Even though Venus disappears behind the Moon before the two objects rise, it reappears while the two objects are in a dark sky. With the Moon at a waning crescent phase, Venus reappears from behind the dark limb of the Moon. You should have no problem seeing the plan-et pop into view if you're looking at the right time — 3:52.9 local time in Honolulu and a couple of minutes later if you're observing from the Big Island. Although you can watch Venus both disappear and reappear from behind the Moon from sites in Mexico and South America, it won't appear as spectacular because the Sun is then well up in the sky. (The map at right shows exactly where the occultation can be seen.)



**A RARE TREAT AWAITS** observers in Hawaii on the morning of October 4. That's when the waning crescent Moon passes between Venus and Earth, occulting Venus from view. Although Hawaiian skywatchers can only see Venus as it reappears from behind the Moon's dark limb (above), they can do so in a dark sky. Observers in parts of Mexico and South America can see the entire occultation, but at the expense of observing during daylight (below).


Entire occultation visible
Reappearance of Venus visible
Venus disappears at sunrise
Entire occultation visible
Disappearance of Venus visible

## *BUT JUPITER PLAYS A MEAN SECOND FIDDLE*

Although Venus dominates the morning sky throughout autumn, Jupiter is also well-placed in the east before dawn and is generally more interesting to observe. As Jeff Kanipe pointed out in last month's Through the Eyepiece, there's always something different to see in Jupiter's cloudtops.

The cause of this activity is turbulence in the Jovian atmosphere. Although there is also considerable turbulence in Venus' atmosphere, that turbulence doesn't mix gases with contrasting colors, as the turbulence in Jupiter's atmosphere does. Thus Venus always appears bland when you view it through a telescope, while Jupiter's appearance changes over time, both on small scales — such as features varying in size, shape, and color — and on large scales — such as the South Equatorial Belt nearly disappearing two years ago.

We'll all have a chance to contrast the atmospheres of Venus and Jupiter this month, when Venus passes just 2° south of Jupiter on October 16/17. Although the separation of the two planets is too great to view both in a single high-power field of view, you can compare their colors in the same low-power field and then inspect their atmospheres individually at high power.

As always, the chart on page 62 shows the relative positions of the four Galilean satellites of Jupiter. This month, we also provide a table (opposite) of the times when you can see the sometimes dominant feature of Jupiter's cloudtops — the Great Red Spot. However, keep in mind the following Great Red Caveats: the Red Spot wanders a bit in longitude, so you should begin observing a bit earlier than the predicted time because the Spot might be early. Also, the Great Red Spot is not usually all that red, but is frequently more salmon-colored. What color will it be this fall? Only time — and chemical impurities in the Jovian atmosphere — will tell.

## SATURN SAVES THE EVENING SKY

It's easy to say that Saturn dominates the evening sky this month — it's the only bright planet that's *in* the evening sky! But this exquisite planet is a rival for any other object in the sky any time it's visible.

Because Saturn lies far south of the celestial equator, Northern Hemisphere observers will find it best to view the planet as it crosses the meridian and thus is as far above the horizon turbulence as possible. Fortunately, this month the ringed planet lies on the meridian during evening twilight, when the atmosphere is in transition from day to night and the seeing is often quite steady.

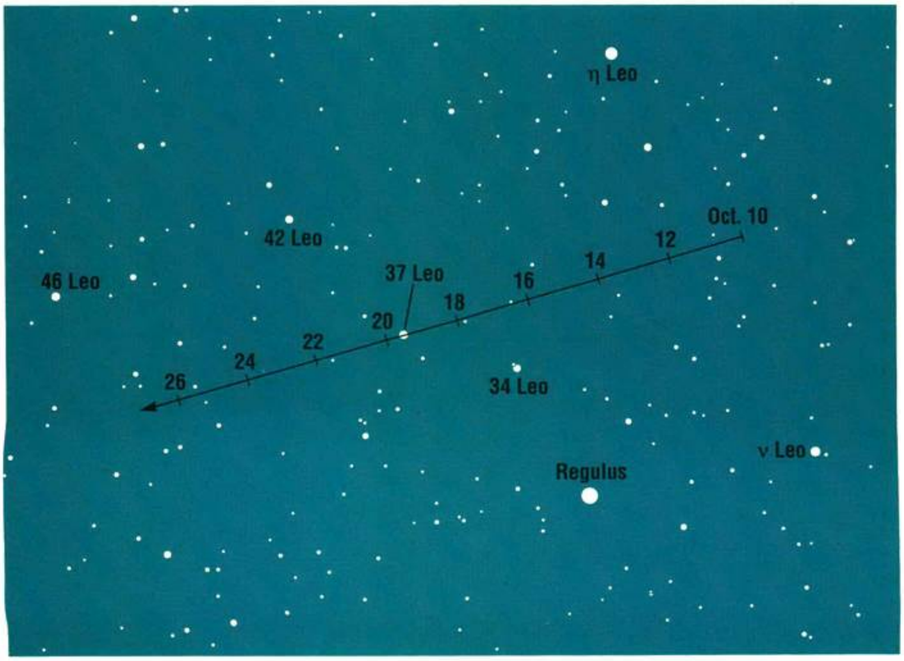
As you examine Saturn in the eyepiece, look for the shadow of the globe of Saturn as it falls on the rings east of the planet. This is particularly easy to see this month because Saturn displays its greatest phase effect. If you can see the shadow clearly, the seeing may be steady enough for you to see both the Cassini and Encke divisions in the rings. And if you see both divisions, you should then be able to make out some detail in the equatorial belt on Saturn itself. If not, try a light blue filter to enhance the view.

Shifting from the difficult to the relatively easy, you should also try to spot Saturn's brightest moons. The ringed planet has four satellites that glow brighter

**COORDINATES FOR VESTA**

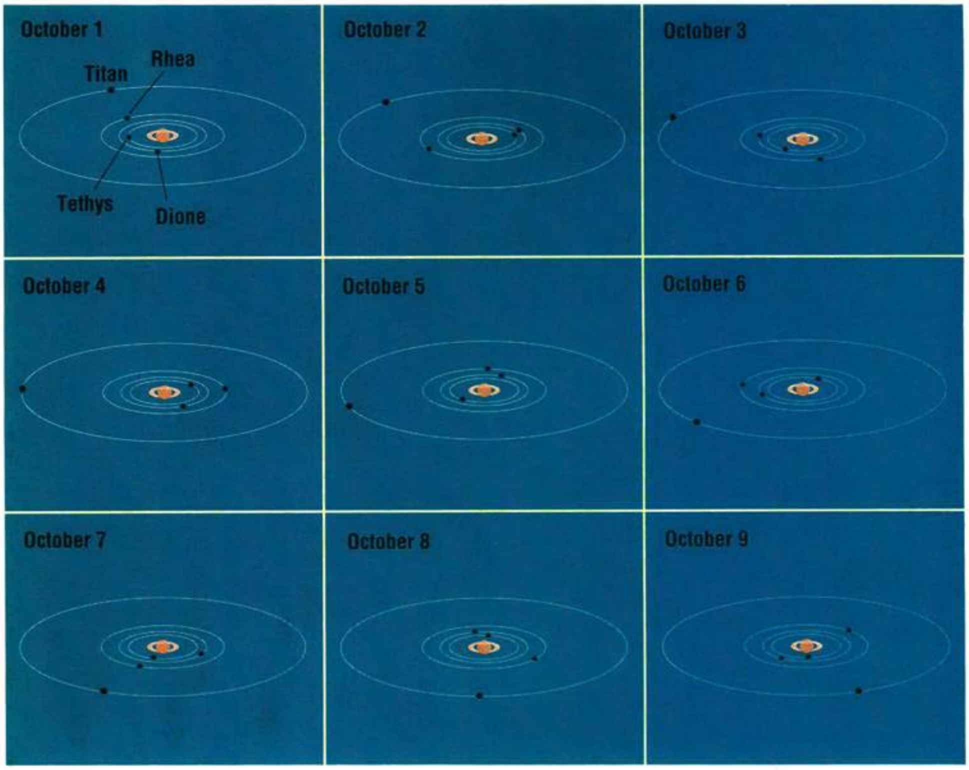
| Date | R.A. (2000) | Dec. |
|---|---|---|
| Oct. 10 | 10h01.5m | 14°47' |
| Oct. 12 | 10h04.7m | 14°34' |
| Oct. 14 | 10h08.0m | 14°20' |
| Oct. 16 | 10h11.2m | 14°07' |
| Oct. 18 | 10h14.3m | 13°54' |
| Oct. 20 | 10h17.5m | 13°40' |
| Oct. 22 | 10h20.6m | 13°27' |
| Oct. 24 | 10h23.7m | 13°14' |
| Oct. 26 | 10h26.8m | 13°01' |

**VESTA TRAVERSES THE STARFIELDS** of Leo in October, passing just 2.4° north of 1st-magnitude Regulus on the 14th and nearly occulting 6th-magnitude 37 Leonis on the 19th. Positions are shown for 5 a.m. EDT (4 a.m. CDT, 3 a.m. MDT, and 2 a.m. PDT).



than magnitude 10.4 and thus are within reach of a 3-inch telescope. Three more satellites glow brighter than 14th magnitude and can be seen in a good 8-inch telescope. However, two of those, Mimas and Enceladus, are difficult to spot because they never stray far from the disk of Saturn, and the third, Iapetus, is difficult to spot because it orbits so far from Saturn that it often blends into the starry background.

The four satellites that you should have little trouble finding are Tethys (magnitude 10.2), Dione (10.4), Rhea (9.7), and Titan (8.3), in order of their distance from Saturn. To spot these moons, use the charts at right, which show the moons' positions on the first nine days of the month when Earth's Moon is out of the way.



**FOLLOW SATURN'S MOONS** — Tethys, Dione, Rhea, and Titan — as they orbit the ringed planet in early October. The satellites' positions are shown at 11 p.m. EDT, (10 p.m. CDT, 9 p.m. MDT, and 8 p.m. PDT). South is at top to match the view in an inverting telescope.

## TELESCOPIC PLANETS

After you get past the big three, this is a rather boring month for planetary observing. Mercury is in superior conjunction on October 3 and returns to view in the evening sky at the very end of the month. Unfortunately, this is a very poor apparition for the innermost planet and you'll be lucky to see it at all (it lies 1° above the west-southwestern horizon 30 minutes after sunset on the 31st). If you do spot it, you'll see a 5"-diameter disk that appears 89-percent lit.

Mars and Pluto are both gone from sight this month, lost in the Sun's glare on the far side of our star. Uranus and Neptune fare a little better, but not much. They can be seen low in the south-southwest shortly after the end of evening twilight. Uranus appears as a 5.7-magnitude, blue-green disk that measures 3.6" across. Its neighbor in the outer solar system, Neptune, shines with a blue-gray light at magnitude 7.9 and displays a 2.2"-diameter disk.

## ASTEROIDS IN THE EYEPIECE

Asteroid 4 Vesta is now returning to view in the morning sky. It shines at 8th magnitude among the background stars of Leo and passes close to two bright stars. The first conjunction is with 1st-magnitude Regulus. Vesta passes 2.4° north of Leo's brightest star on October 14. The second conjunction is even closer. On October 19, Vesta passes so close to the 6th-magnitude star 37 Leonis that it may occult the star (the orbit of Vesta is not known precisely enough to know for sure whether an occultation will take place). Unfortunately, the event is not visible from the Western Hemisphere. If an occultation does occur, the best place from which to view it is East Asia. Use the finder chart or table of coordinates opposite to track Vesta's motion through Leo this month. □

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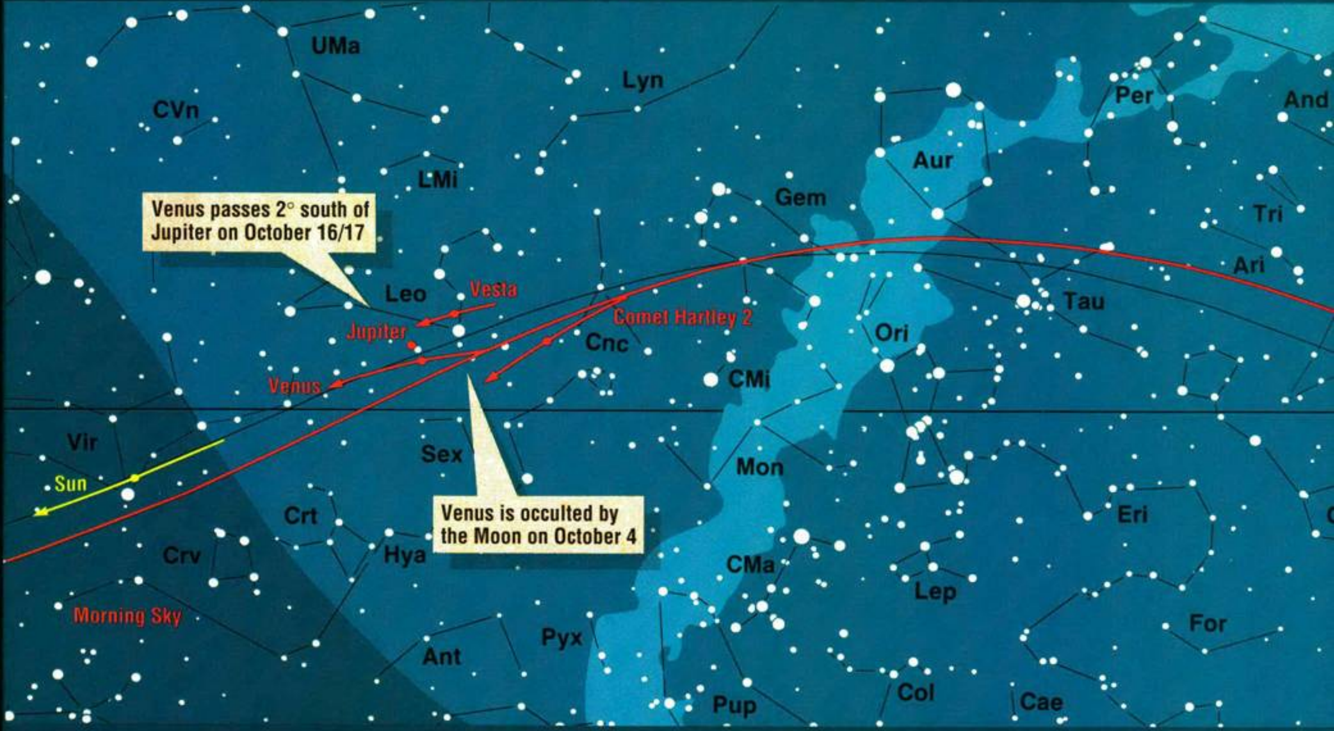
*Rick Shaffer is a technical group leader at the Jet Propulsion Laboratory in Pasadena, California. He leads the data management team on the Ulysses mission, a spacecraft on its way to Jupiter and the Sun.*

## GREAT RED SPOT TRANSIT TIMES

| Date | Time |
|---|---|
| October 4 | 6:11 a.m. EDT |
| October 6 | 7:49 a.m. EDT |
| October 9 | 5:20 a.m. EDT |
| October 11 | 6:59 a.m. EDT |
| October 16 | 6:08 a.m. EDT |
| October 18 | 7:47 a.m. EDT |
| October 21 | 5:17 a.m. EDT |
| October 23 | 6:56 a.m. EDT |
| October 25 | 8:35 a.m. EDT |
| October 26 | 4:26 a.m. EDT |
| October 28 | 5:05 a.m. EST |
| October 30 | 6:43 a.m. EST |
| October 31 | 2:35 a.m. EST |

The Red Spot can be seen for two to three hours before and after the transit times listed. All times are eastern time; subtract 1 hour to convert to central, 2 hours for mountain, and 3 hours for pacific.

# The Solar System  October 1991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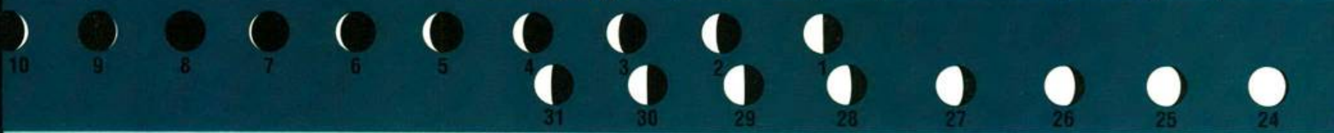
Venus passes 2° south of Jupiter on October 16/17

Venus is occulted by the Moon on October 4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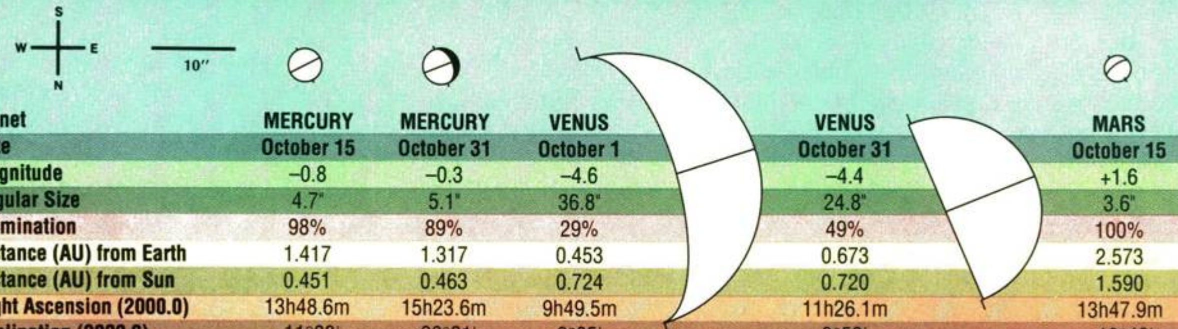
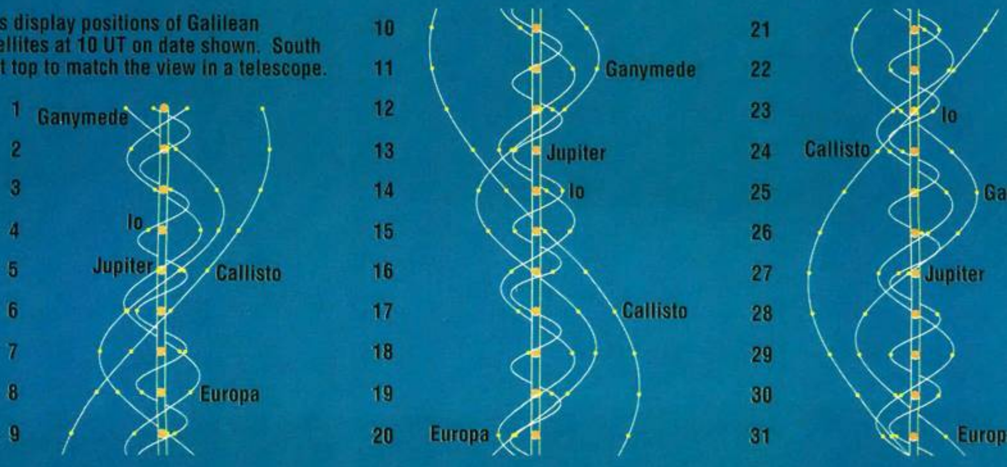
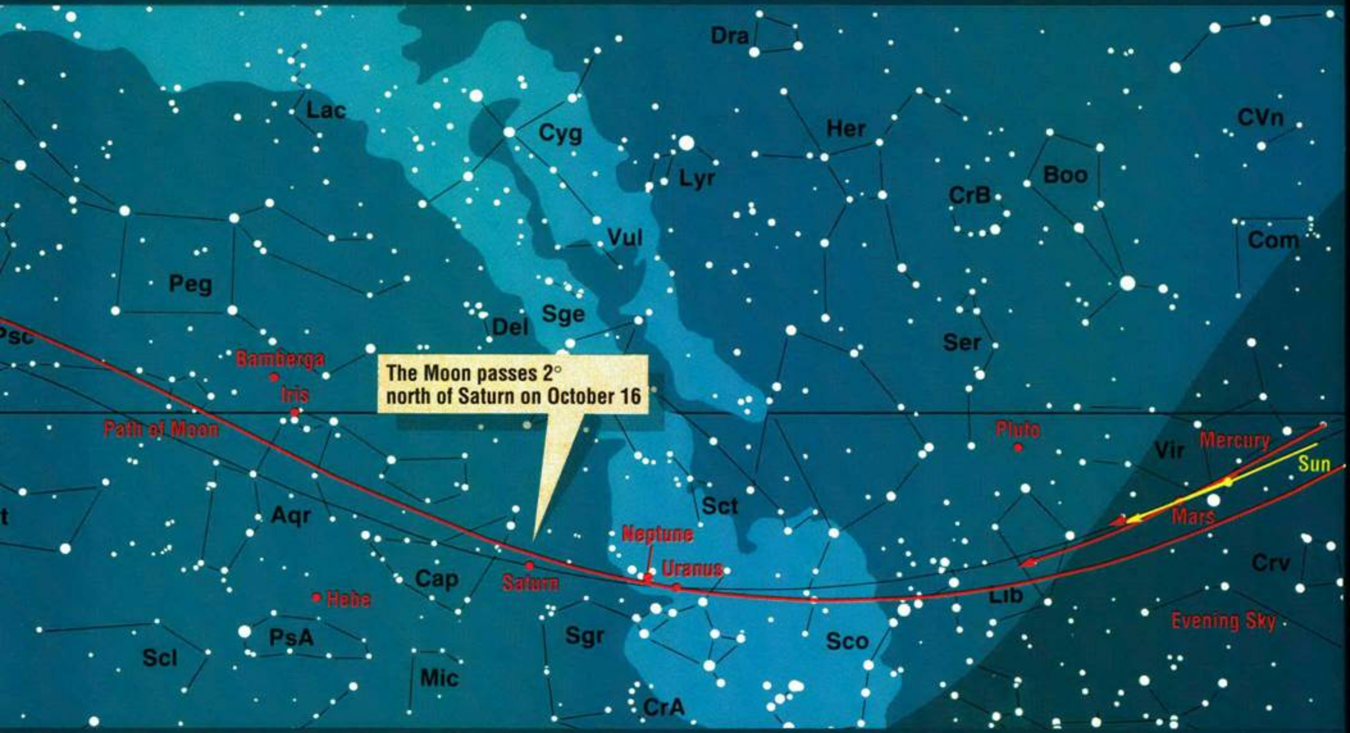


| Planet | MERCURY | MERCURY | VENUS | VENUS | MARS |
|---|---|---|---|---|---|
| Date | October 15 | October 31 | October 1 | October 31 | October 15 |
| Magnitude | –0.8 | –0.3 | –4.6 | –4.4 | +1.6 |
| Angular Size | 4.7" | 5.1" | 36.8" | 24.8" | 3.6" |
| Illumination | 98% | 89% | 29% | 49% | 100% |
| Distance (AU) from Earth | 1.417 | 1.317 | 0.453 | 0.673 | 2.573 |
| Distance (AU) from Sun | 0.451 | 0.463 | 0.724 | 0.720 | 1.590 |
| Right Ascension (2000.0) | 13h48.6m | 15h23.6m | 9h49.5m | 11h26.1m | 13h47.9m |
| Declination (2000.0) | –11°08' | –20°21' | 9°05' | 3°52' | –10°48' |

## Jupiter's Moons

Dots display positions of Galilean satellites at 10 UT on date shown. South is at top to match the view in a telescope.

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Pluto
Vir
Mercury
Sun
Sct
Aqr
Mars
Neptune
Crv
Cap
Uranus
Saturn
Lib
Hebe
Evening Sky
PsA
Sgr
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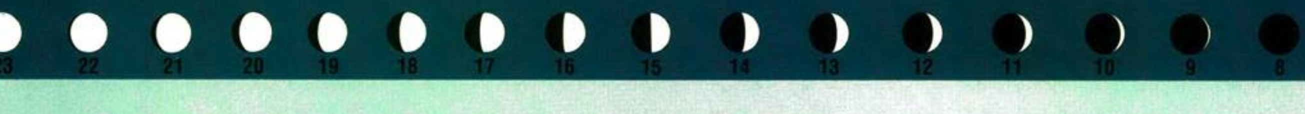
CrA

The Moon passes 2° north of Saturn on October 16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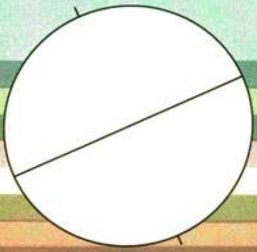
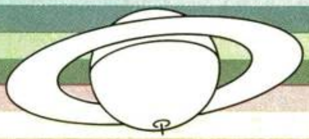
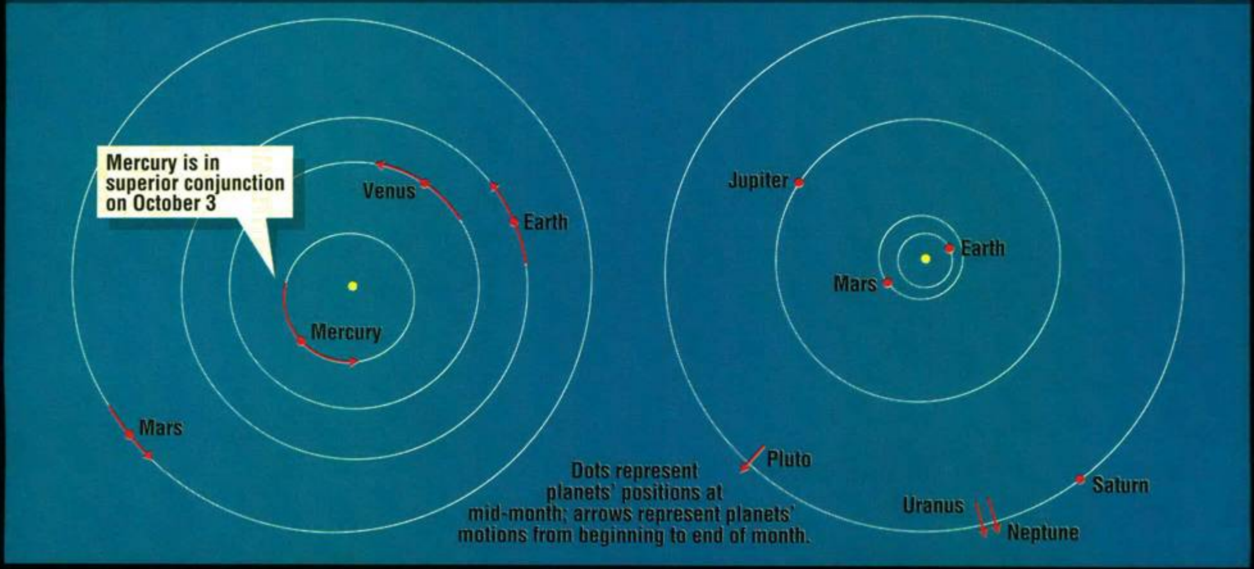




| JUPITER October 15 | SATURN October 15 | URANUS October 15 | NEPTUNE October 15 | PLUTO October 15 |
|---|---|---|---|---|
| –1.8 | +0.5 | +5.7 | +7.9 | +13.8 |
| 32.6" | 17.0" | 3.6" | 2.2" | 0.1" |
| 100% | 100% | 100% | 100% | 100% |
| 6.034 | 9.742 | 19.662 | 30.303 | 30.530 |
| 5.369 | 9.949 | 19.496 | 30.196 | 29.682 |
| 10h34.9m | 20h10.8m | 18h44.6m | 19h01.3m | 15h23.0m |
| 9°53' | –20°36' | –23°25' | –21°55' | –3°31' |

## The Planets in Their Orbits


Venus
Earth
Mercury
Mars
Jupiter
Earth
Mars
Pluto
Saturn
Uranus
Neptune

Mercury is in superior conjunction on October 3

Dots represent planets' positions at mid-month; arrows represent planets' motions from beginning to end of month.

# FIRST REPORT: The Day the Sun Went Out

It was cloudy in places it was supposed to have been clear, and clear in places it should have been cloudy. But all told, more people saw the July 11 eclipse of the Sun than any other in history.

by the editors of ASTRONOMY

Eclipses are always surprises. Sure, timings can be calculated down to the second many years in advance. And the location of the shadow's path can be plotted to an accuracy of tens of meters. But all the precise predictions and detailed descriptions fail to prepare you for what you finally see. Or more to the point — what you finally *feel*.

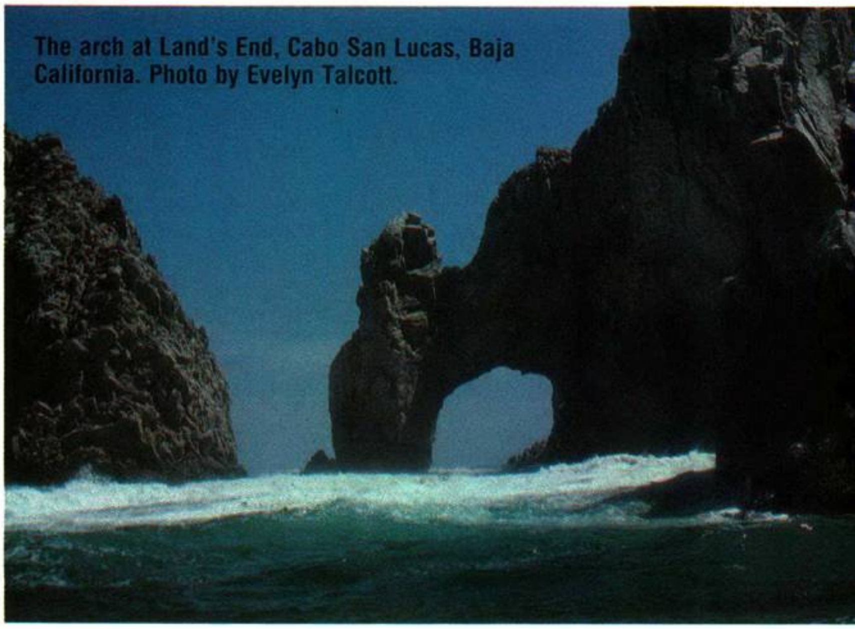
As one member of our expedition, actor Patrick Stewart (star of *Star Trek, The Next Generation*) described it, "All of the technology that brought me to this place left me unprepared for the emotional experience that followed. The eclipse was so overwhelming it will take me a long time to decipher all that I saw and felt."

Five hundred other people on our expedition, and the many thousands of others who traveled to Mexico for the eclipse, would probably agree. (Scattered throughout this report are selected quotes from fellow members of our expedition.)

In our case, we were part of the second largest group to travel to this eclipse. ASTRONOMY editors Alan Dyer, Dave Eicher, and Richard Talcott joined the Twilight Tours expedition to the Los Cabos area at the southern tip of Baja California. (Richard Berry was on board the cruise ship *Viking Serenade* in the Sea of Cortez. His report appears on page 72.) For 75 percent of the people on our tour, this was their first eclipse. Not one of them left unimpressed. Even veteran eclipse chasers ranked this event as superlative, with a corona that was one of the finest they had seen.

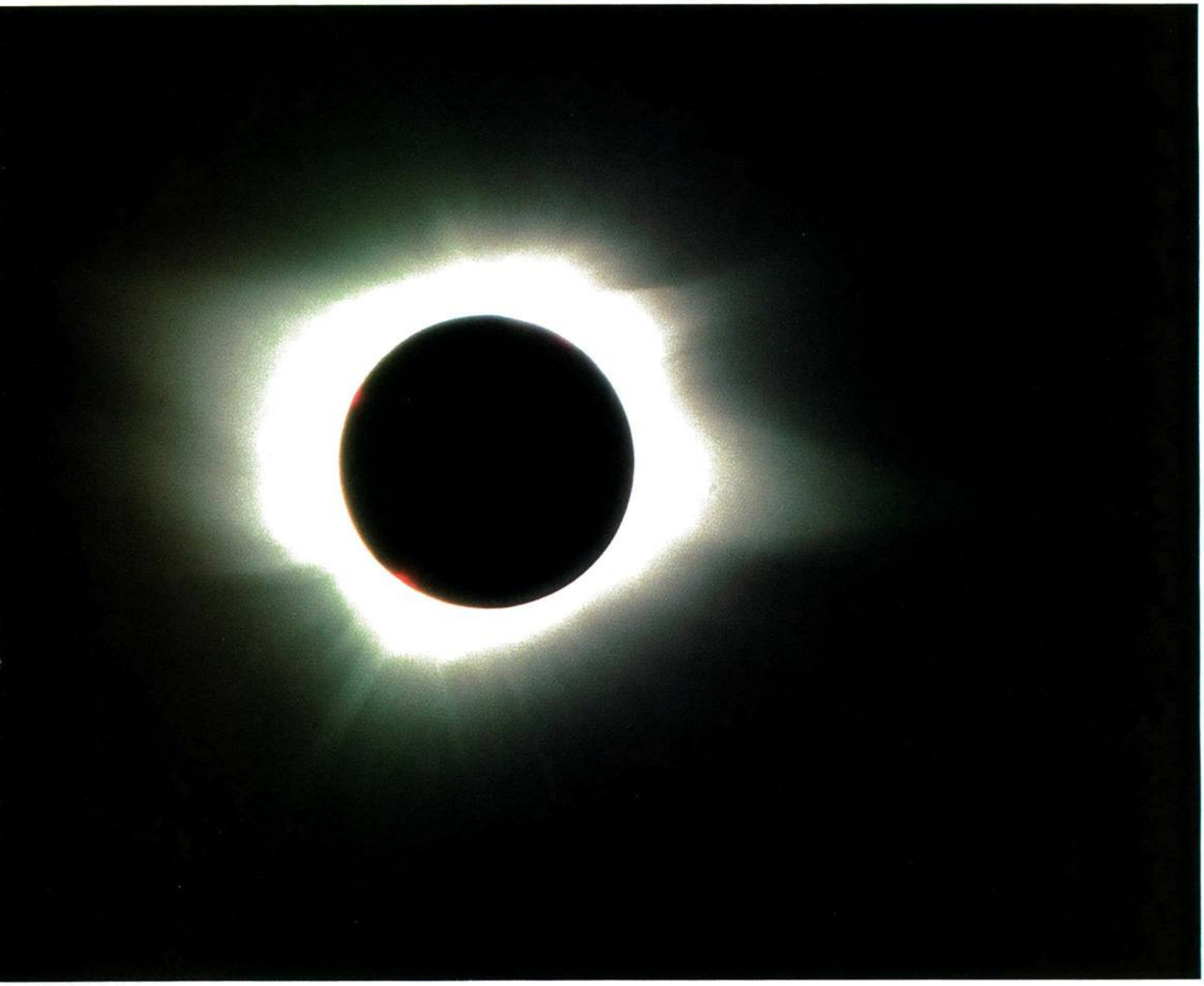
Two massive prominences poked out from behind the Moon's disk and remained visible for the entire duration of totality. This was another eclipse surprise — the Moon was large enough that it should have covered most prominences at mid-totality. But not these. These red tongues of hydrogen made their mark as one of the most memorable features of the 1991 eclipse.

**THE CORONA** (opposite page) was painted with delicate brushstrokes of light streaming in all directions. Photo by Andrew Steinbrecher taken from San José del Cabo, Baja California, with a 700mm lens, Ektachrome 50 film, and a 1/2-second exposure.

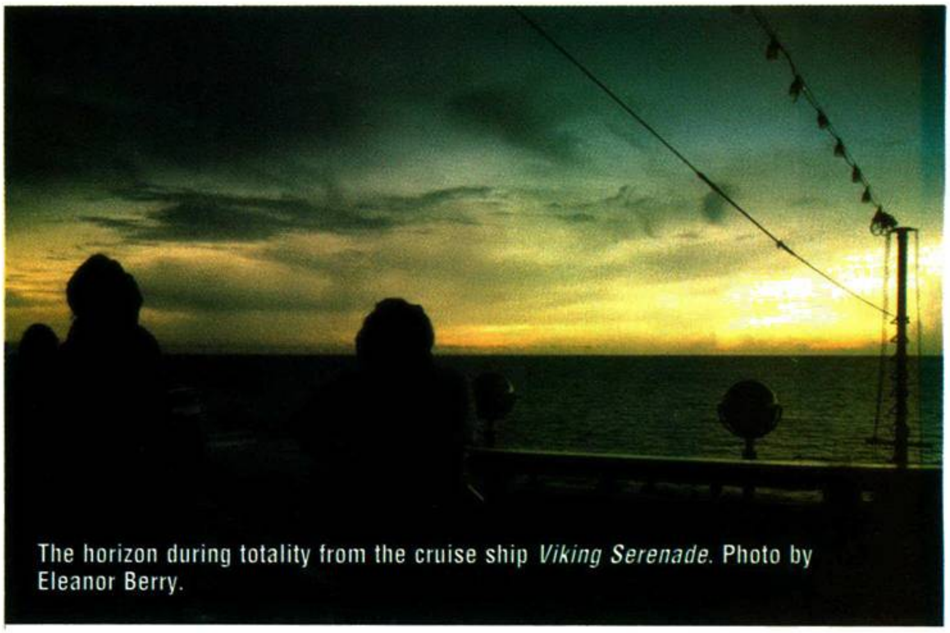


The arch at Land's End, Cabo San Lucas, Baja California. Photo by Evelyn Talcott.

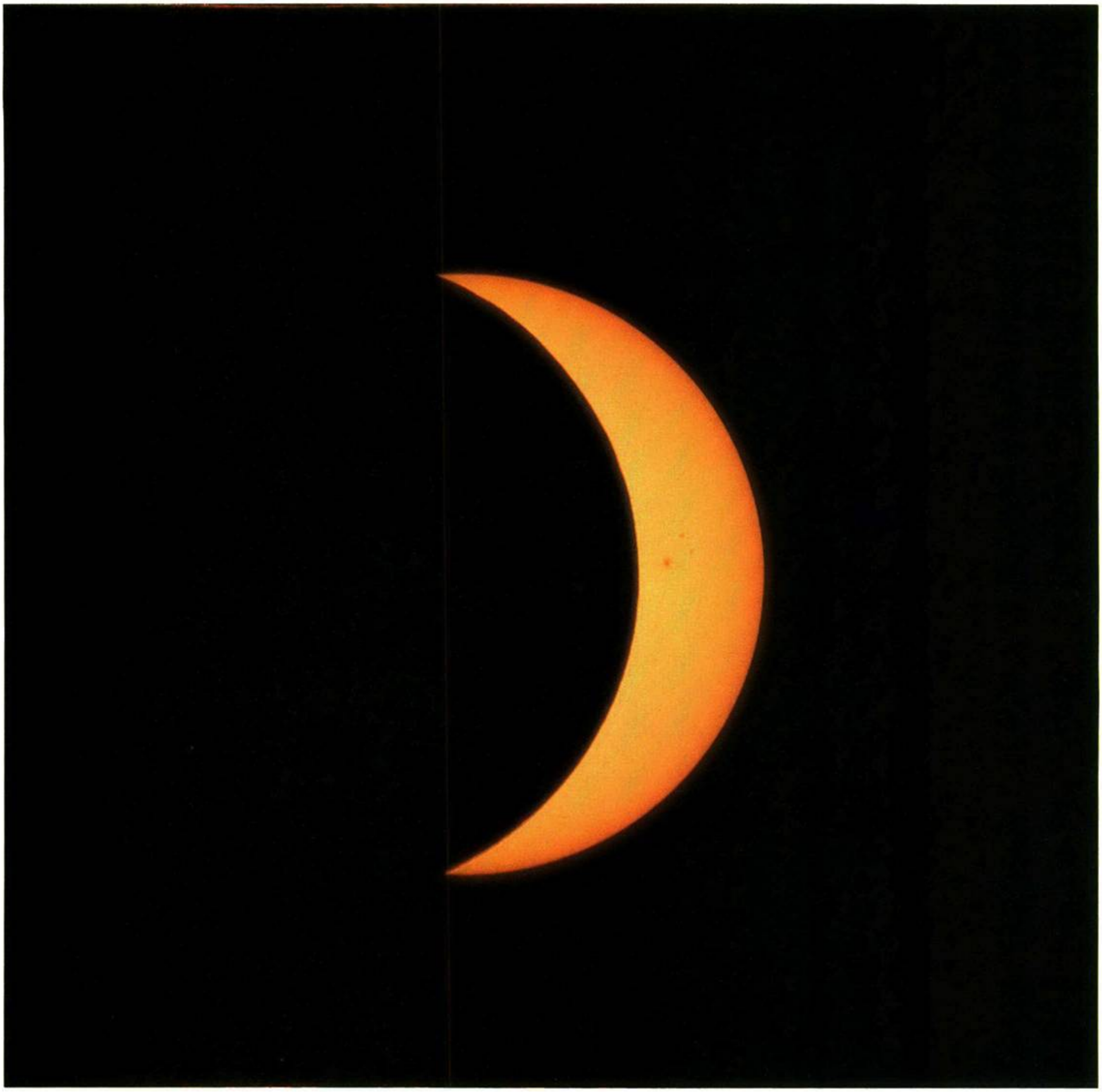
**"It seemed like someone tied a ghostly bow around the Sun."**

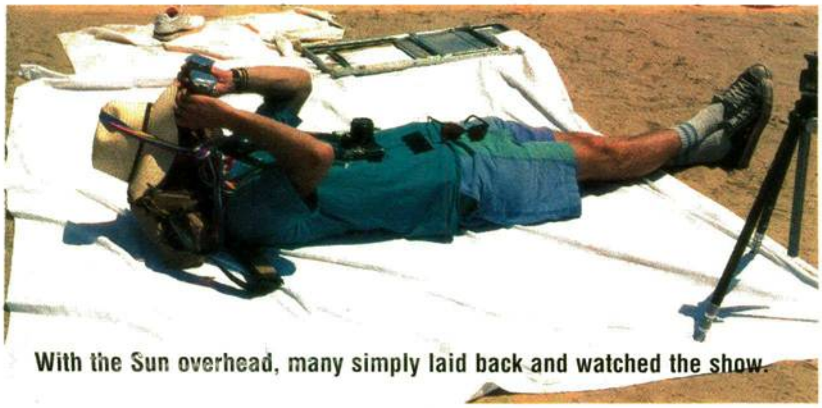


Waiting for the eclipse in the Baja desert.



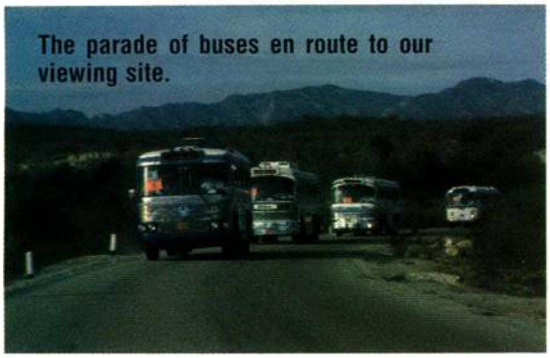
The horizon during totality from the cruise ship *Viking Serenade*. Photo by Eleanor Berry.



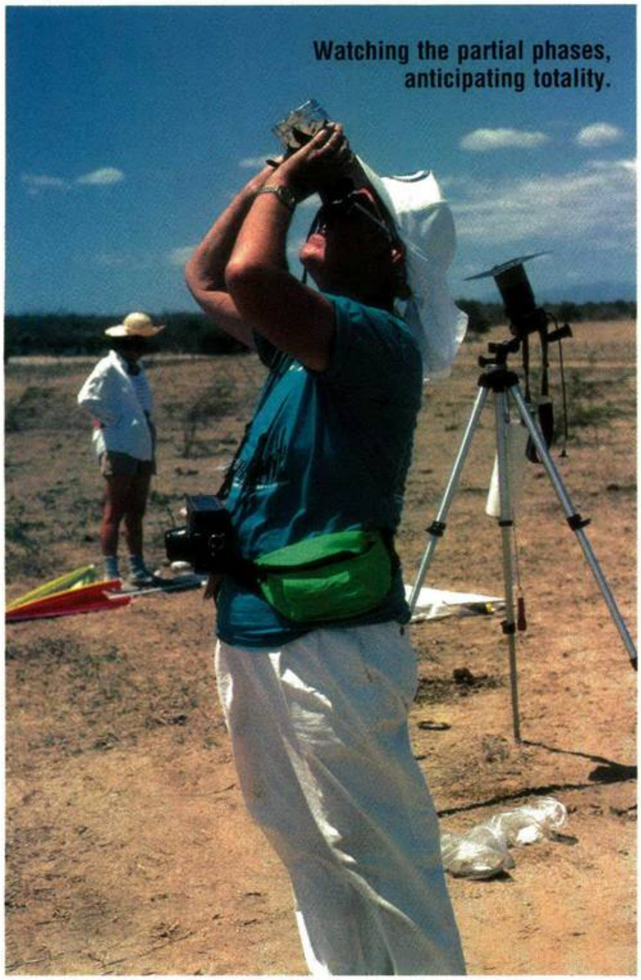


With the Sun overhead, many simply laid back and watched the show.

**AS THE PARTIAL ECLIPSE** progressed, the temperature went down and the excitement level went up. Photo by Alan Dyer, taken with a Takahashi FC-76 refractor and Kodachrome 64 film at f/16 and 1/8-second exposure.



The parade of buses en route to our viewing site.



Watching the partial phases, anticipating totality.

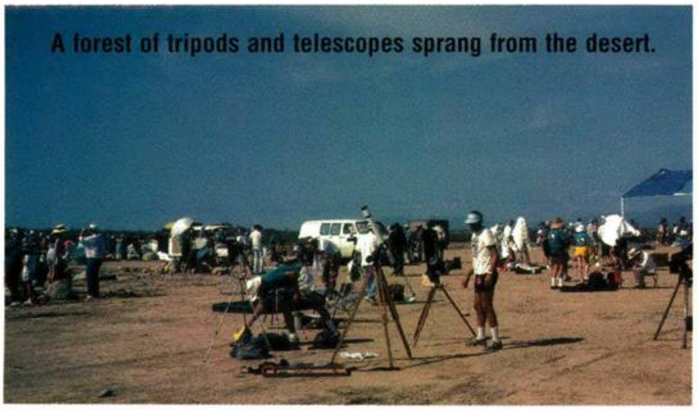
Our Twilight Tours eclipse site was located near the centerline not far from the town of Santiago. It was a nearly ideal spot, with the central mountains of the Baja Peninsula to the west and the Sea of Cortez in the distance to the east. We were able to see for many miles in all directions, an important factor in enjoying a total eclipse. The rapid approach and departure of the Moon's shadow and the changing colors near the horizon are as impressive as the sight of the eclipsed Sun itself.

A total of 13 buses brought us from our coastal hotels to our chosen rendezvous point with the lunar shadow. As the buses unloaded, what had been a barren field turned into acres of tripods and telescopes in only a few minutes. Everyone spent the morning checking, aiming, loading film, rechecking, re-aiming, waiting for those long-awaited few minutes of darkness.

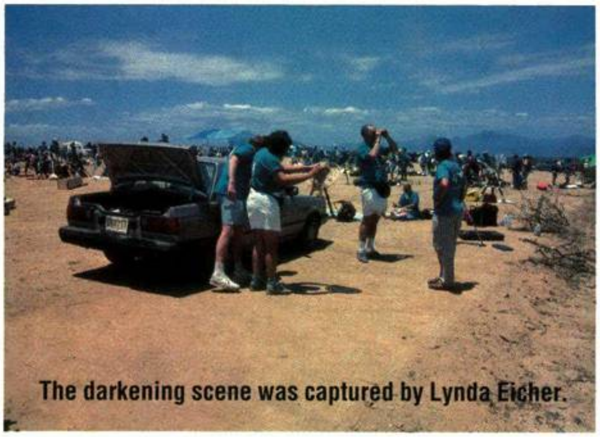
The wait was a hot one. At mid-morning before the start of the eclipse, the temperature was 92° in the shade, with a ground temperature of 110°. The onset of the eclipse brought a welcome cooling trend. By totality, the temperature had fallen to 82° — it seemed refreshingly cool. In the early partial phases, the wind gusted at times but, surprisingly, at totality the wind died down.

Seeing the eclipse with a group as large as this one is an experience in itself. As Stewart put it, "I was especially glad to be in the company of others. There was a unity of spirit that intensified the emotional impact." The shouts that went up as the Sun disappeared, the exclamations of joy at the sight of the corona, and the cheers as the Sun returned echoed across our eclipse site and added much to the memory of the day.

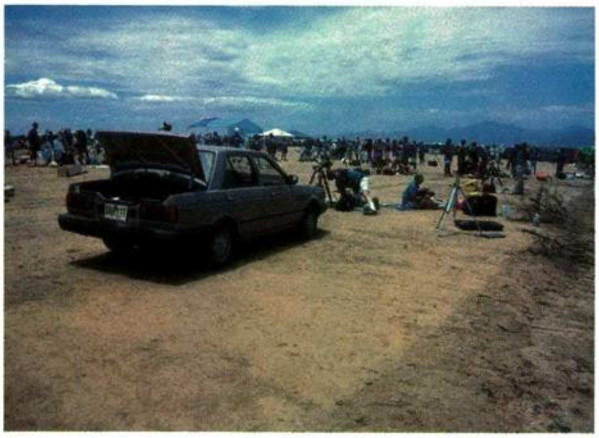
**"I felt a surge of wonder and pride. I was part of what was happening, within it all."**

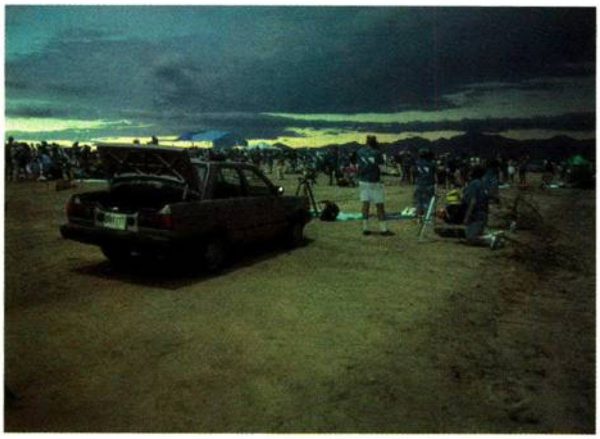


A forest of tripods and telescopes sprang from the desert.



The darkening scene was captured by Lynda Eicher.





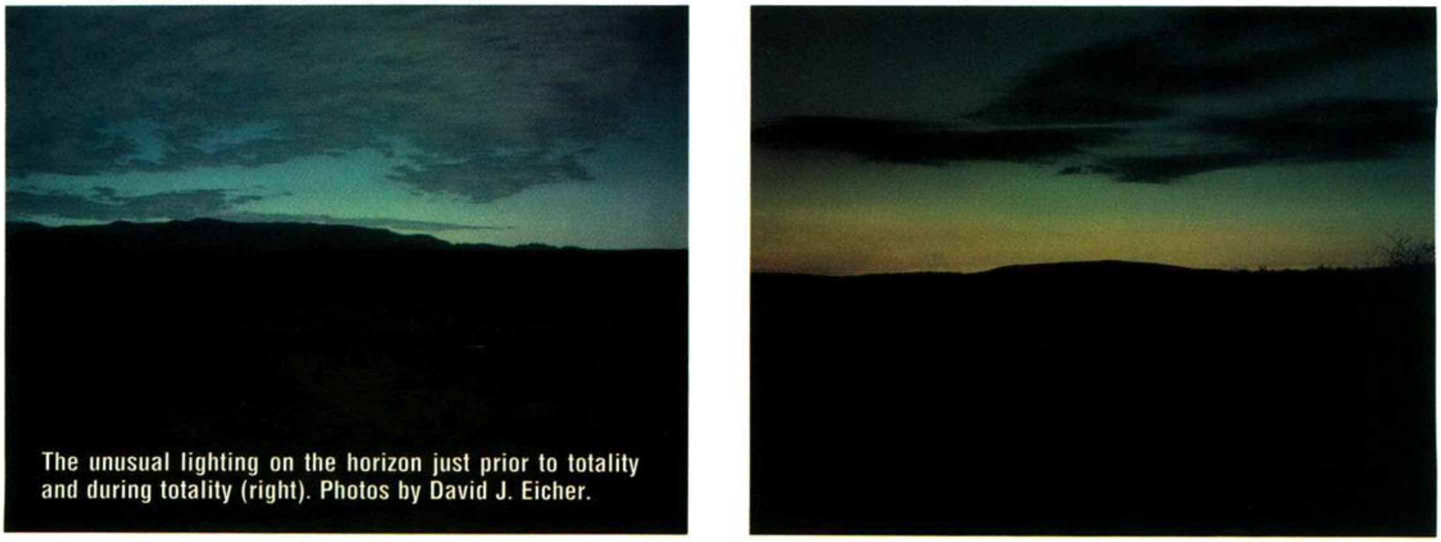
**"The eclipsed Sun looked lonely. It was eerie."**

**THE UNEARTHLY SKY** during totality is one of the highlights of every eclipse. At our Baja site, clouds obscured the view for part of totality. Photo by David J. Eicher taken with a 28mm lens on Kodachrome 64 film.

**"The darkness just enveloped us."**

Another surprise at this eclipse was that the sky didn't get very dark during totality. At least not from our site. Considering the size of the Moon's shadow, most eclipse watchers expected the sky to get dark enough that bright stars would become visible at mid-totality. As it was, Venus was easy to see, even before the onset of totality and some observant folks saw Jupiter, but few in our group spotted Mars, Mercury, or any bright stars.

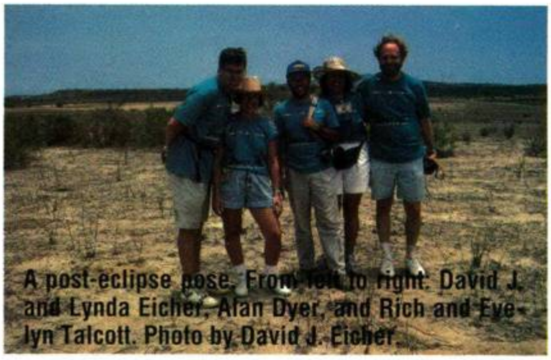
Even at mid-totality there was enough light to see camera settings, landscape details, and the few hundred other eclipse-goers surrounding us, each of them occupied with cameras, telescopes, and the sheer difficulty of taking it all in during the brief moments of totality. "It's amazing how fast seven minutes of totality goes by while seven minutes of work seems to last all day," remarked one expedition member.



The unusual lighting on the horizon just prior to totality and during totality (right). Photos by David J. Eicher.

**"The prominences were surprising. I could see them with the naked eye."**

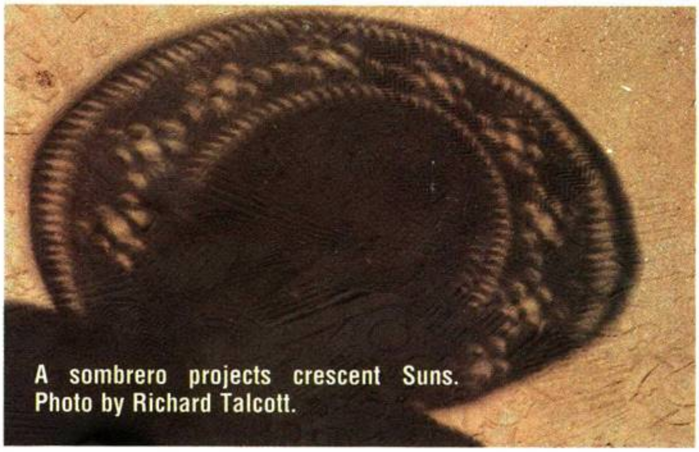
**GIANT TONGUES OF FLAMING RED GAS** reached out from the solar surface and from behind the Moon's disk. Close-up of the largest prominence by Alan Dyer using a Takahashi FC-76 refractor at f/16 and Kodachrome 25 film.



A post-eclipse pose. From left to right: David J. and Lynda Eicher, Alan Dyer, and Rich and Evelyn Talcott. Photo by David J. Eicher.

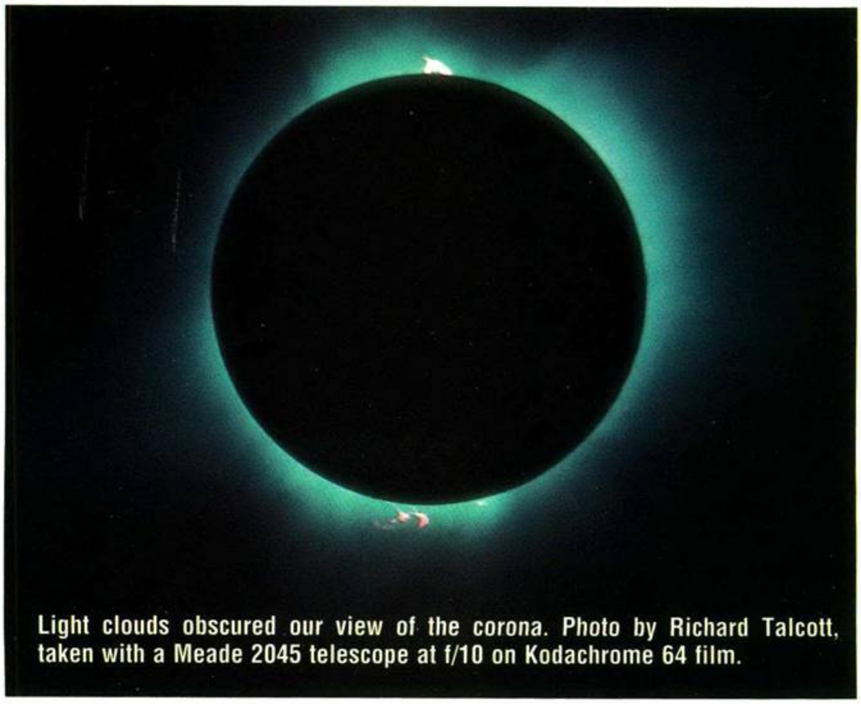
We expected hot weather — we got hot weather. We expected humidity — we got humidity. We expected clear blue skies — we got, well, clouds. As the eclipse progressed and the temperature dropped, the only clouds on the entire Baja Peninsula the morning of July 11 formed right over our humid eclipse site. A chant started: "Clear! Clear! Clear!" If we had had pots and pans we would have banged them together to drive off the evil cloud spirits that were taking the eclipsed Sun from us.

All was not lost. Far from it. We saw the first 3 minutes of totality very well and the end of totality as the Sun emerged from behind the Moon. But the loss of half of totality to rapidly formed clouds dampened the group's post-eclipse excitement. "Only 50 percent satisfaction!" one member shouted out. Of course, when we returned from our inland site to the coast, we found that those who had stayed back at the comfort of the beach hotels had seen the entire event. Yes, eclipses are always surprises.



A sombrero projects crescent Suns. Photo by Richard Talcott.

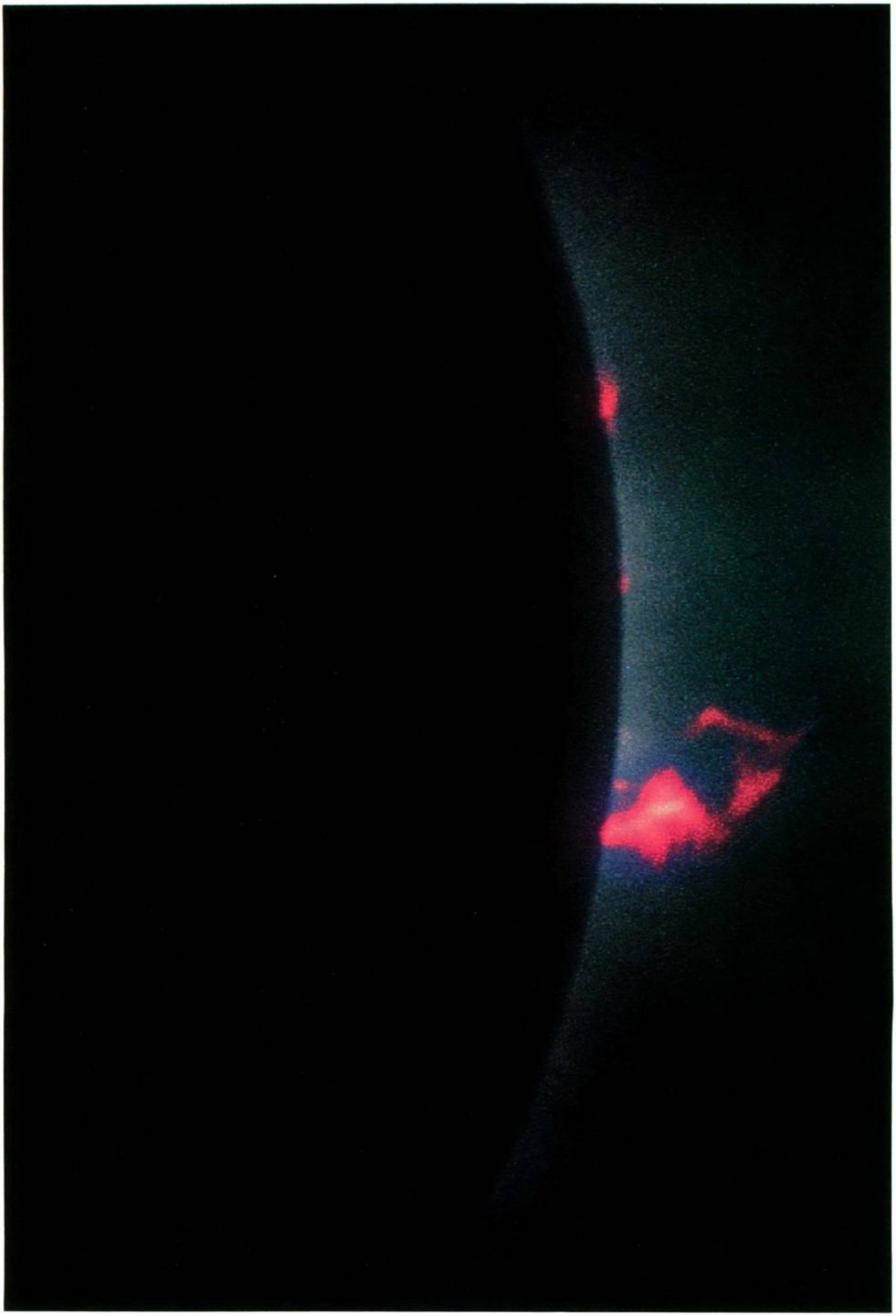
**"Out of ten eclipses, I've never seen the weather change so fast."**



Light clouds obscured our view of the corona. Photo by Richard Talcott, taken with a Meade 2045 telescope at f/10 on Kodachrome 64 film.

EL EJERCITO Y FUERZA
AEREA MEXICANOS EN
AUXILIO AL TURISTA

Emergency assistance was never far away.

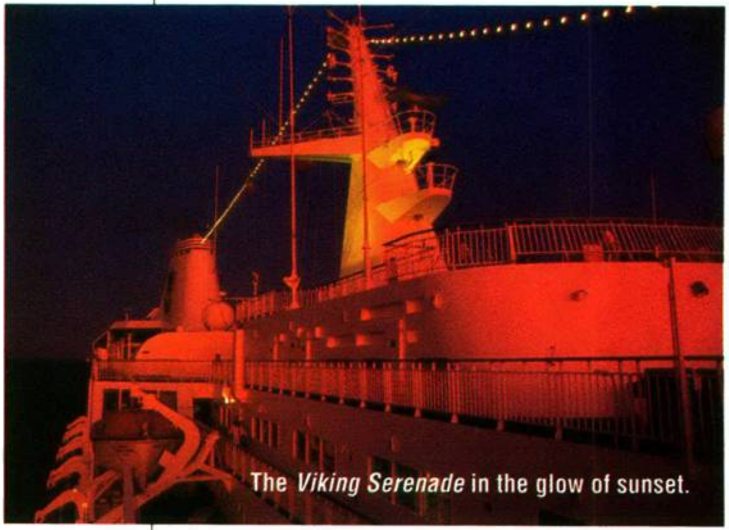


"The eclipse looked just like a piece of white paper with a black part in the middle," pronounced five-year-old Annmarie Garfinkle, adding "I *saw* it!"

Annmarie was one of 1,300 passengers aboard the Royal Caribbean Line's *Viking Serenade* who saw totality in the clear blue sky over the Sea of Cortez. Although clouds over mainland Mexico threatened our sky in the morning, once the *Viking Serenade* turned and steamed toward Baja California, we soon outdistanced them. When the Sun's corona bloomed huge and bright and pearly, we had a perfect view.

I was aboard, as one of the faculty of the Adler Planetarium and Love to Travel, to help other passengers enjoy the eclipse and to coach hundreds of eclipse-goers in the art of eclipse photography. Co-instructor Richard Horwitz and I presented lectures on eclipse viewing and photography, gave hands-on workshops, and answered hundreds of last-minute questions.

The ship's captain with Eleanor and Richard Berry.


The *Viking Serenade* in the glow of sunset.

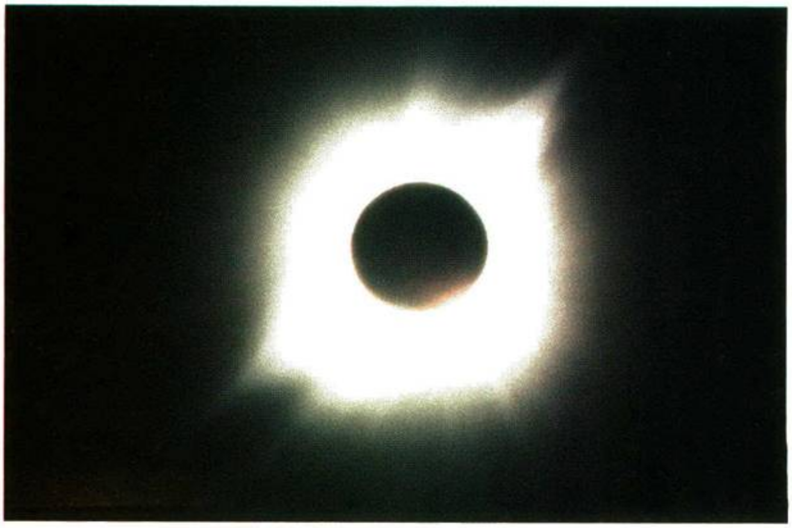
I had a 1000mm f/10 mirror-lens, and I shot my pictures with a large prism over the lens to disperse the Sun's light into a spectrum over one degree long.

As totality approached, I glued my eye to the viewfinder of the 1000mm lens. Although the spectrum was dazzlingly bright, I could now see the dark Fraunhofer lines. Only seconds remained. The arc of visible photosphere dwindled. A gleaming pattern of bright emission lines from the chromosphere grew in brightness. The pure red of hydrogen-alpha and the blue-green of H-beta shone vividly, and I could see the ionized calcium lines in the deep violet and the yellow-orange doublet of sodium.

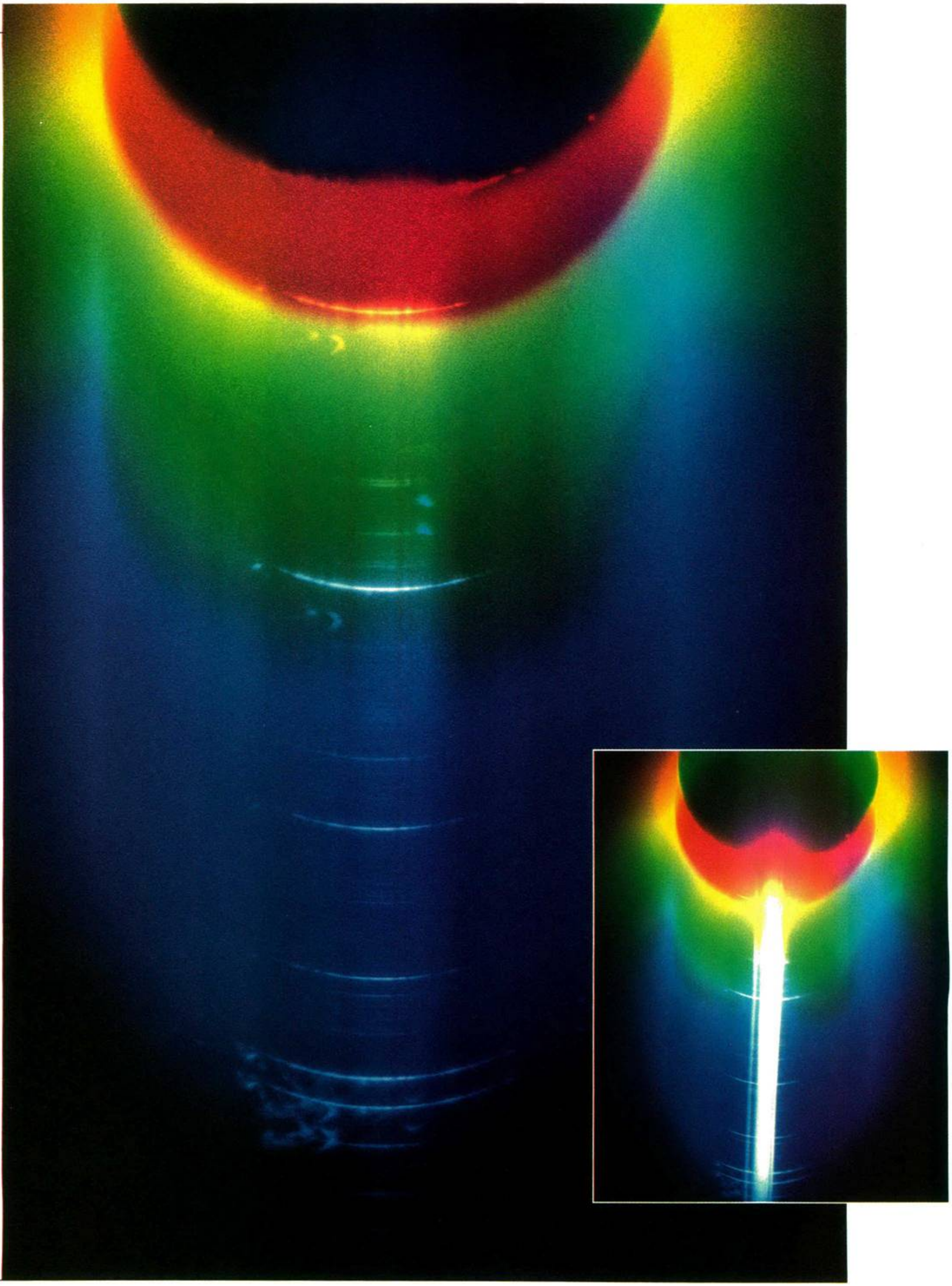
As the Moon advanced, it covered the chromosphere and the flash spectrum faded. I shot several frames showing the spectrum of the corona, then removed the prism and aimed the lens at the Sun. Even in the camera viewfinder, the solar corona was awesome. Delicate filaments and tendrils seemed to crisscross the inner parts of the corona, and long streamers stretched to the very edges of the frame. Pictures do not even begin to convey the glory of this eclipse — a tribute to the power and subtlety of the human eye and brain. — *Richard Berry*

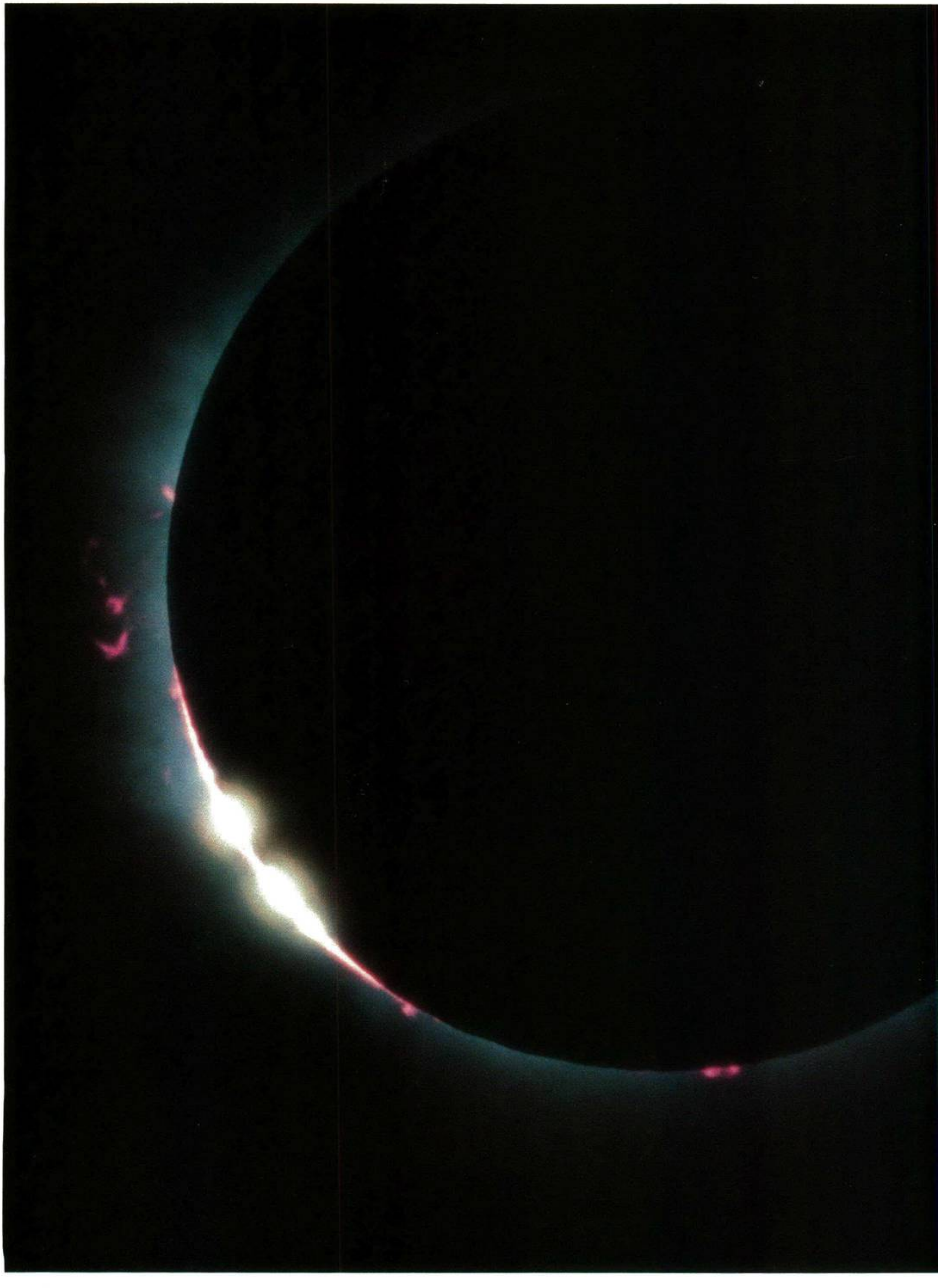
**FLASH! THE SPECTRUM** of the solar chromosphere (right) tells its tale of chemical elements and solar physics as a brilliant wash of pure color. Photos by Richard Berry.

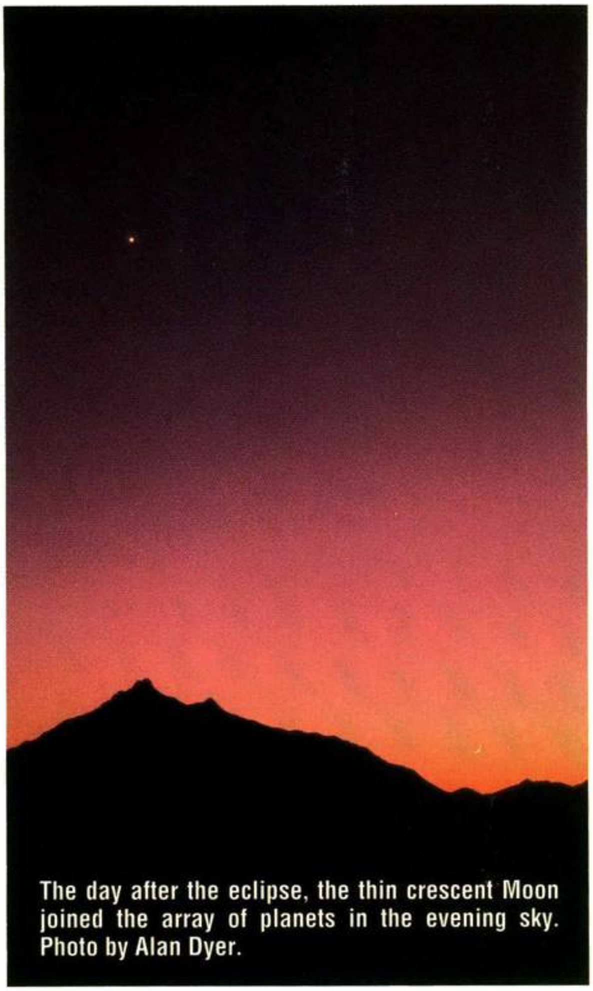
**"Pictures do not even begin to convey the glory of this eclipse."**



**LONG STREAMERS** extending to three times the Sun's diameter characterized the Sun's corona on July 11. Photo by Richard Horwitz using a 600mm telephoto at f/4 on Ektachrome 200 film, 1/30-second exposure.







The day after the eclipse, the thin crescent Moon joined the array of planets in the evening sky. Photo by Alan Dyer.

> **"When it was over, my feeling was one of optimism and hope."**

**THE DIAMOND RING** at second contact was captured by Paul Severance from Cabo San Lucas using a Meade 2045 f/10 telescope, Ektar 125 film, and 1/250-second exposure.

Though we had some clouds at our Twilight Tours site, it could have been worse. Some groups only a few miles away from us had clouds through most of totality. Many in Hawaii were clouded out entirely, even those on the Kona coast, a location that was supposed to have been clear. The summit of Mauna Kea was above the clouds but dust from the Mount Pinatubo volcano in the Philippines blanketed the upper atmosphere and turned the normally crystal-clear Mauna Kea skies into a milky haze. This severely curtailed the professional observations, especially those in the infrared portion of the spectrum.

Elsewhere in Mexico, clouds also covered Mazatlán on the west coast though, as expected, eclipse chasers along the coast south of Mazatlán managed to find clear areas at eclipse time. On the other hand, a location that was almost guaranteed to be cloudy, Mexico City, turned out to be clear, giving the city's 12 million inhabitants an unexpected chance to see the sky's greatest spectacle. Eclipse watchers near Oaxaca, in southern Mexico, also beat the odds and were treated to a grand view of the eclipse.

As we were assembling this story in the days immediately following the eclipse, reports and photos from readers all along the eclipse path were beginning to pour in. Next month we'll feature an extended roundup of what other people saw and photographed during what turned out to be truly an extraordinary eclipse. — *Alan Dyer, David J. Eicher, and Richard Talcott*

# When Galaxies Go Wrong

High-resolution, long-exposure amateur astrophotographs reveal a universe of galaxies with twisted and distorted lives. It's a hidden world of galaxies gone wrong.

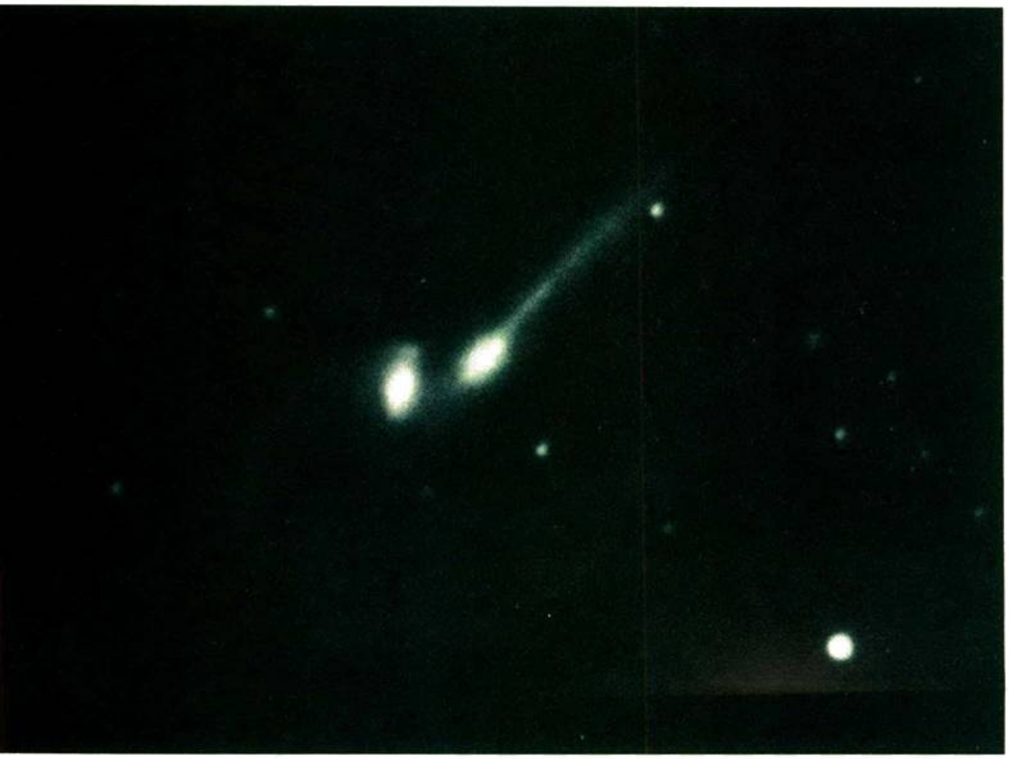
by David J. Eicher
Photographs by James R. Foster

Space is a BBIIIIIIGG place. There's so much room out there that trillions of stars orbit peacefully about the centers of galaxies, and galaxy clusters millions of light-years across gyrate slowly past each other on opposite sides of enormous dark voids. In our Galaxy alone there's so much room that if the nearest spiral arm were teeming with life we might well never know it, the distances for travel or communication being so vast.

Yet close encounters of the worst kind do occur in space — luck has a way of turning on objects in the universe, just as it does on people on Earth. A normal, innocent spiral galaxy can one day find itself in the wrong place at the wrong time. In the throes of a gargantuan collision with a massive elliptical, the spiral's very identity can be destroyed and its contents torn away and spilled out into intergalactic space. This is a story of the bad-luck oddities in the extragalactic zoo, the genuine victims of the unlikely that pass through existence in normal states until a catastrophic event destroys or mutates them forever. This is a story of galaxies gone wrong.

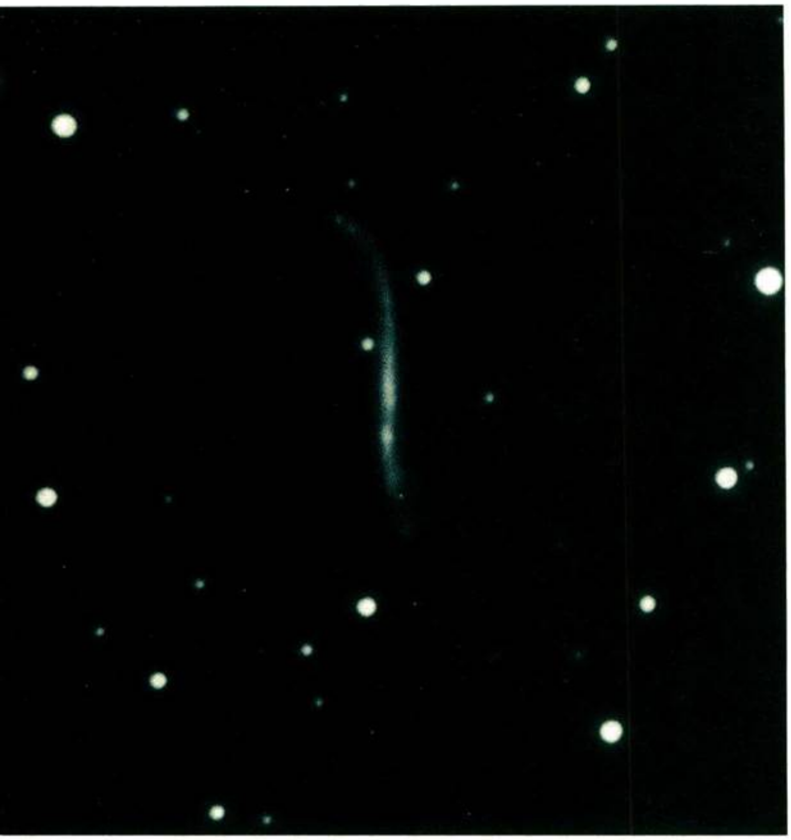
"Take the case of NGC 660 in Pisces," says James R. Foster. "It's a really strange system in which a faint, luminous ring of material seems to be encircling the nucleus. And the galaxy's dust lanes seem to be distorted such that they appear at right angles to each other. Something terribly weird took place in the history of this galaxy." Foster should know. He frequently travels from his home in Hollywood, California, to nearby Mt. Pinos for photographic sessions. Equipped with an 11-inch SCT, endless rolls of hypersensitized Tech Pan film, and incredible patience, Foster has produced a rogues' gallery of unusual and interacting galaxies.

NGC 68 is one of Foster's favorites. The brightest member of a compact group of galaxies in Andromeda, NGC 68 offers a rich hunting ground for extragalactic oddities. "It's a fascinating field," says Foster. "I counted 20 galaxies within the area of the cluster's core and thought that NGC 70 was the most peculiar. It seems to have a halo of material shared by other members of the galaxy group surrounding it." Could NGC 70 be the monster galaxy whose gravitational tug will shred matter from its neighbors? This is certainly the case in other clusters, and one wonders about the chaotic ruins of



**THE PECULIAR, TWISTED SHAPE** of NGC 520 in Pisces suggests the merger of two galaxies (opposite page). Mysteriously, astronomers have found a large number of quasars near this galaxy (a single quasar is arrowed).

**A CELESTIAL DANCE** that will last millions of years is being performed by the galaxies NGC 4676A and NGC 4676B, nicknamed the Mice (left). The long tail of material drawn away from one galaxy was caused by tidal interaction with the other.



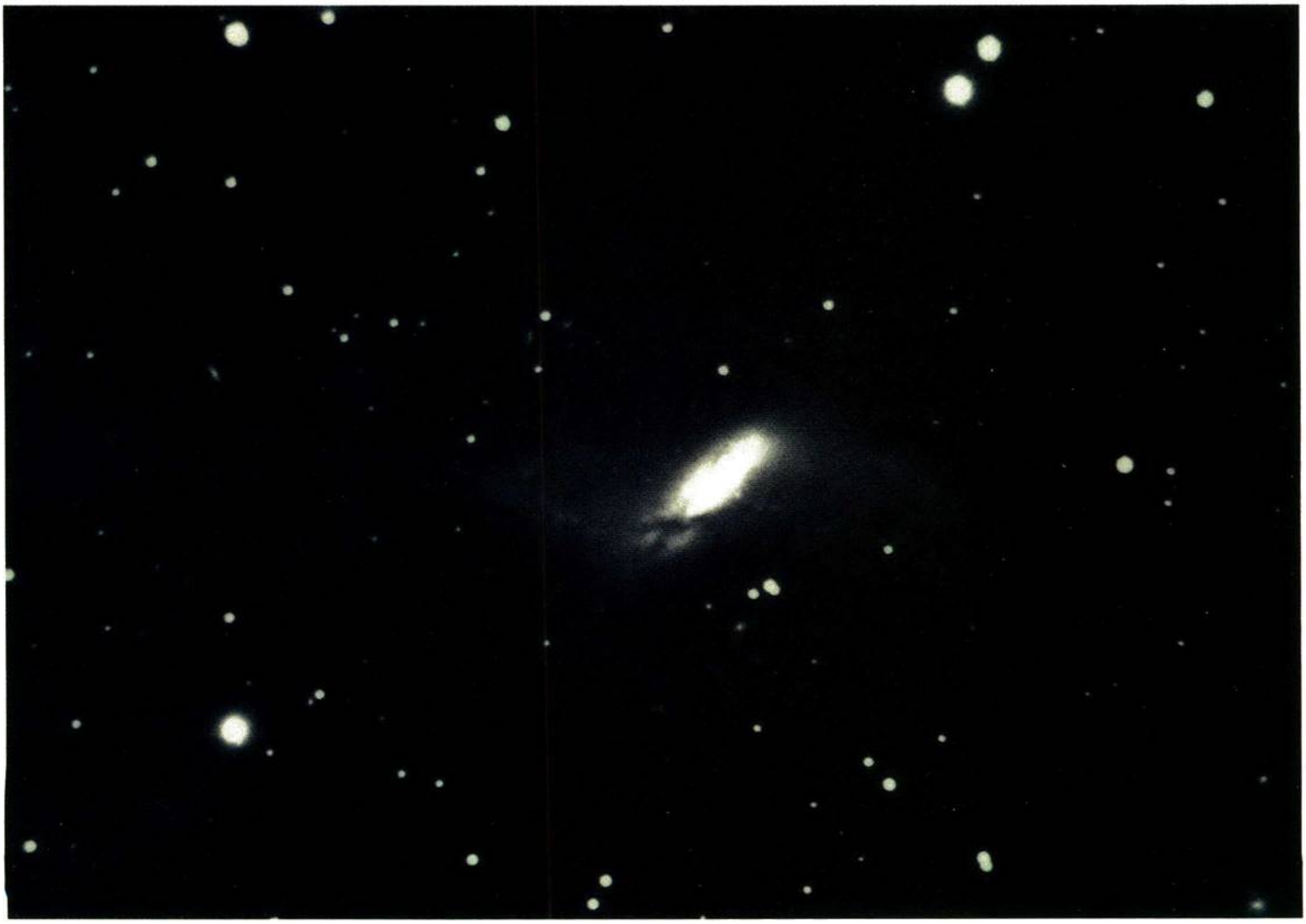
once great spirals laid to waste by the hungry masses that surround them.

Not all galaxies are cannibals, however. Some interactions between these majestic star systems are much less catastrophic, much tamer to be sure. "There's the case of NGC 2535 and NGC 2536, two galaxies in Cancer," remarks Foster. "These objects form a classic case of galaxy interaction — a little high-speed interloper whizzing by a larger, more stable spiral. The result is that material is being drawn away from a spiral arm of the larger galaxy, and will be cast out into the empty coldness of intergalactic space."

Ah, to be enjoying a starry day at the beach in a spiral arm of NGC 2535. This galaxy is a slowly spinning wheel of starstuff minding its own business, an innocent member of the Local Supercluster. And then comes the realization. One starry day at the beach you realize that your piece of the galaxy is drifting away,

**FLAT AS A PANCAKE,** galaxy UGC 3697 in Camelopardalis nonetheless shows curled lips on both ends (left). Is this peculiar feature the remnant of interaction with a passerby?

**A FAINT LUMINOUS RING** encircles the peculiar galaxy NGC 660 in Pisces (below). Additionally, the contorted dust lanes in this galaxy appear to intersect at right angles. Did this object undergo some turbulent interaction in the distant past?



away to the loneliness of deep space. You then discover that nature is truly ambivalent, uncaring one way or the other. Nature is simply the unfolding story of events as time relentlessly marches on.

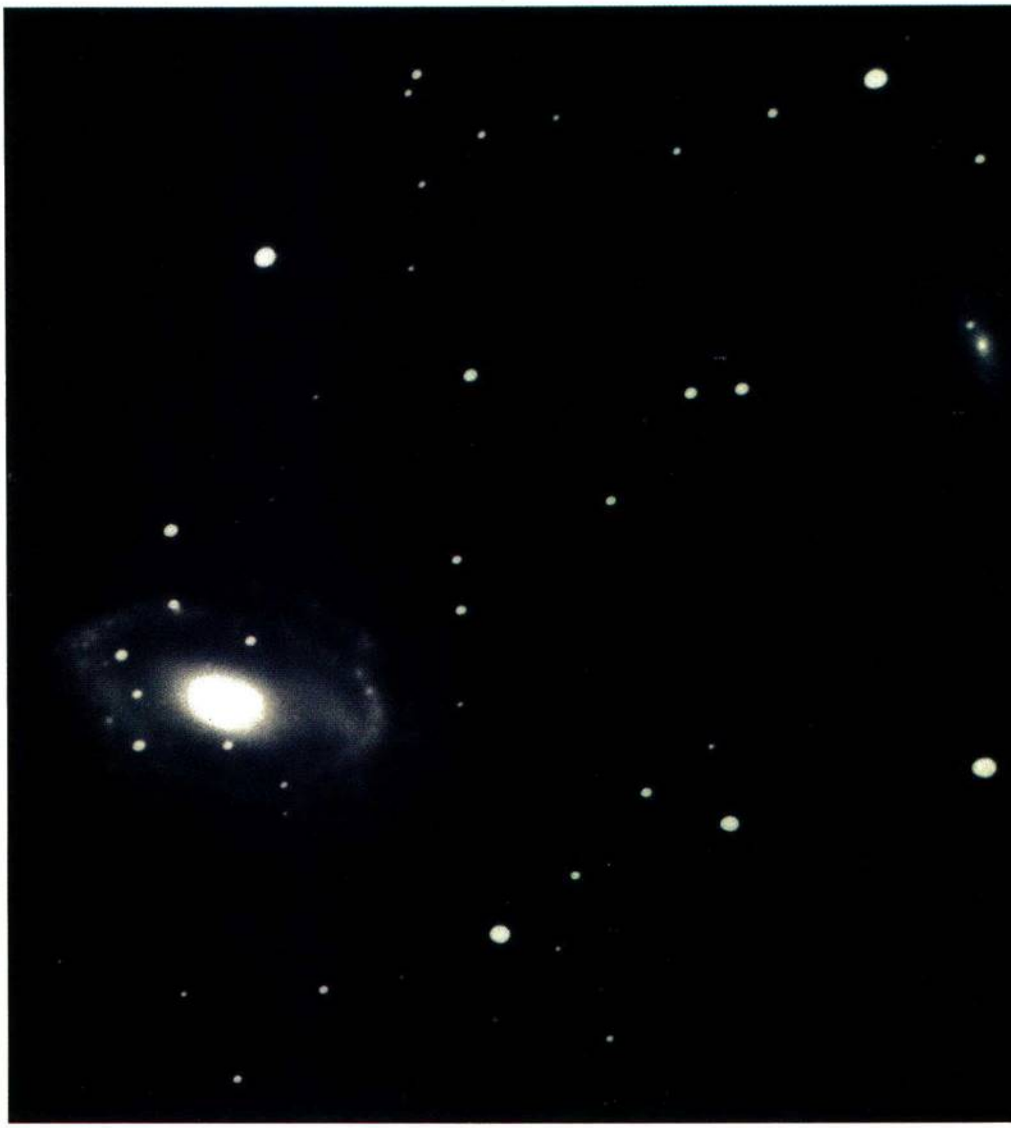
Of course an event like a galaxy's losing a spiral arm following a cataclysmic collision with another galaxy takes millions of years to unfold. We simply get to see one frame in the great, ongoing cosmic movie.

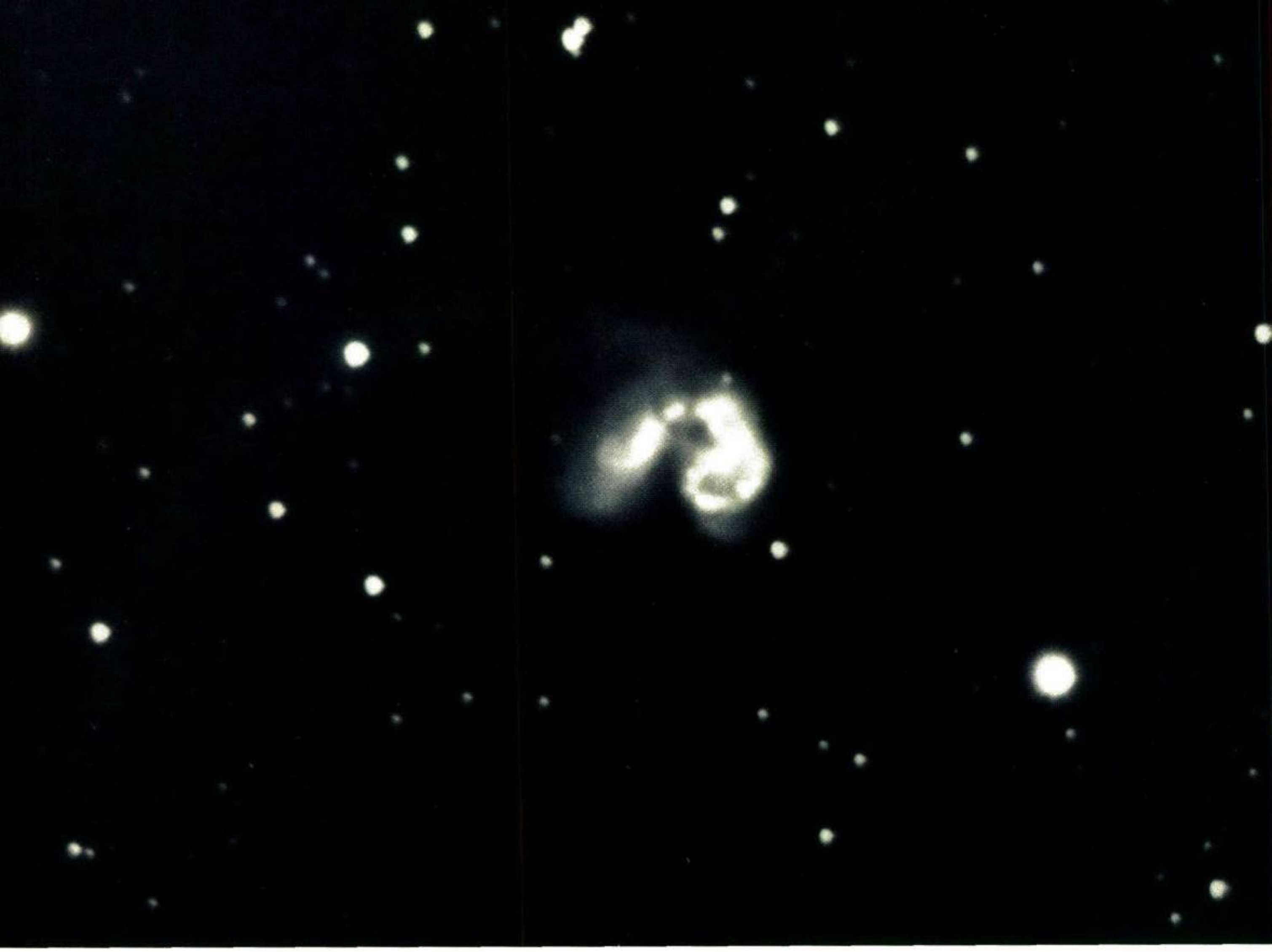
The great distances between stars and gas clouds, even in the centers of galaxies, mean that in a collision most objects would pass through undisturbed. Yet the magnitude of the destructive power in a galaxy collision is mindbending. A look at galaxies like the Ringtail Galaxy in Corvus (NGC 4038-9), NGC 520 in Pisces, or the Mice in Coma Berenices (NGC 4676A and NGC 4676B) invokes a reasonably unpleasant picture of life near the center of one of those objects. What high-energy fun is transpiring inside these galaxies? Is life on any planet able to cope with it? It's the stuff that will employ science fiction writers until Doomsday.

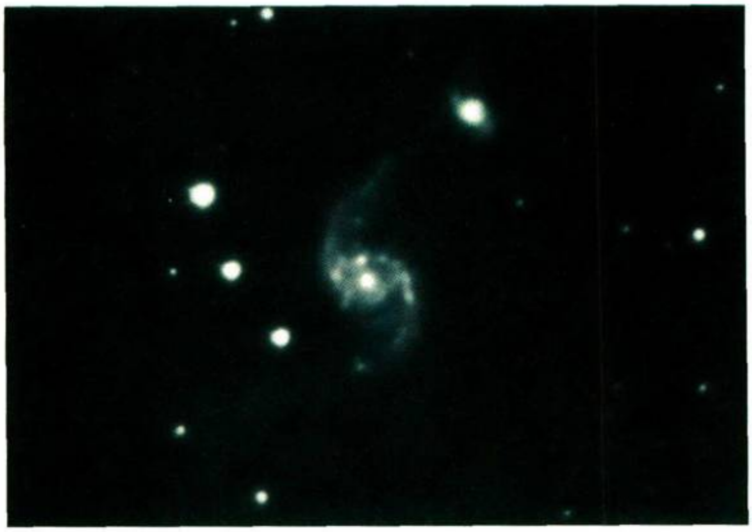
In a long series of letters, James Foster takes all of this in stride. He is happy to be collecting a superb set of galaxy photographs that show some of the most famous members of the astrophysical zoo — the freak show candidates that draw every large scope owner's instant attention at star parties. After commenting on the

**GLOWING BALLS OF LIGHT**, the galaxies in the NGC 68 group share a common envelope of dust and gas (above). Galaxies in such tight groups sometimes pull each other apart gravitationally, feeding on each other's material until a few victorious super-galaxies are left.

**SCATTERED DECEPTIVELY** throughout the universe are interacting galaxies. Astronomers need to determine accurate distances to galaxies to show whether an apparent interaction is really taking place. For example, a keen-eyed guesser might suggest a link between galaxies NGC 4725 and NGC 4712 (right). However, NGC 4712 lies four times farther away than NGC 4725. On the other hand, the radial velocities of NGC 3718 and NGC 3729 (below) show that these galaxies are indeed interacting.







**THE RINGTAIL GALAXY** in Corvus is a spectacular example of two galaxies locked in interaction. Visible with small telescopes, the peculiar, kidney-shaped galaxies have been distorted substantially by each other's gravitational tug.

**NGC 2535 and NGC 2536** are interacting galaxies in Cancer (left). The small, high-speed interloper (NGC 2536, above right in photo) is drawing material away from one of the larger galaxy's spiral arms.

galaxies in his letters, Foster is happy for the time being not to know all the answers. "Please share these pictures with your readers and clear skies and good weather to you," he invariably writes. After reading each letter, I wish *him* good weather, for he is capturing a superb group of stills from the great cosmic movie.

Some prints spill out from an envelope on my desk and I find myself face to face with NGC 520. A really textbook-weird galaxy, NGC 520 seems to have a twisted disk with two bright components and a curving dust lane, all of which is bathed in an envelope of faint gas in a peculiar, distorted shape. To heighten the weirdness, some years ago astronomer Halton Arp suggested that the seemingly large number of faint quasars around this galaxy may be nearby objects that were shot out from the galaxy's nucleus. One of these quasars is visible in Foster's latest photo of the galaxy. The galaxy could hardly be more distorted. Looking carefully at this troubled soul, I can scarcely think of another thing that could be screwed up in this galaxy's structure. I think about the many worlds that might exist there, the peculiar view of things one might have from a planet near the dust lane. It is a queer place, this NGC 520. It is truly a galaxy gone wrong. □

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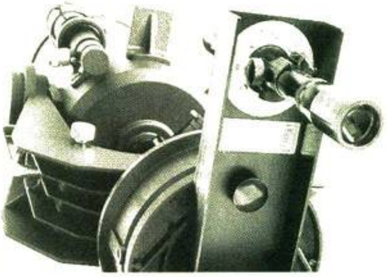

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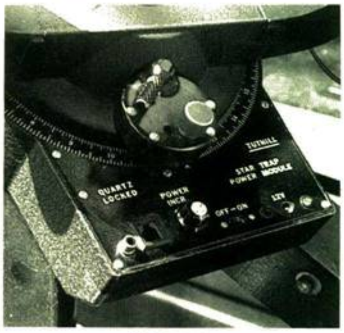

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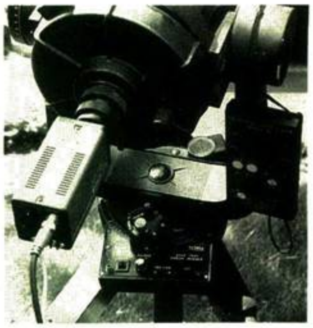

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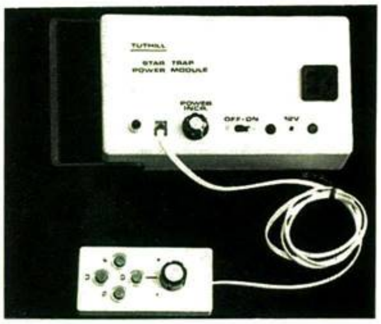

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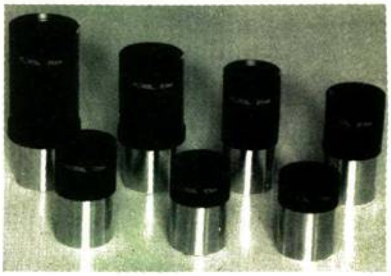

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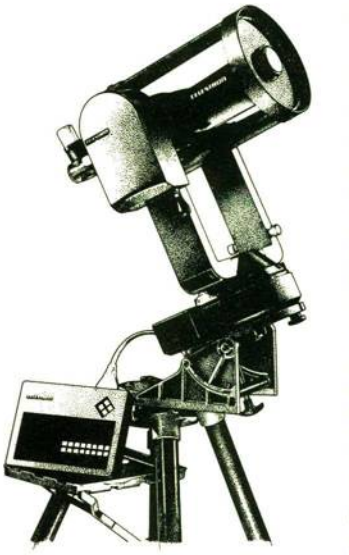

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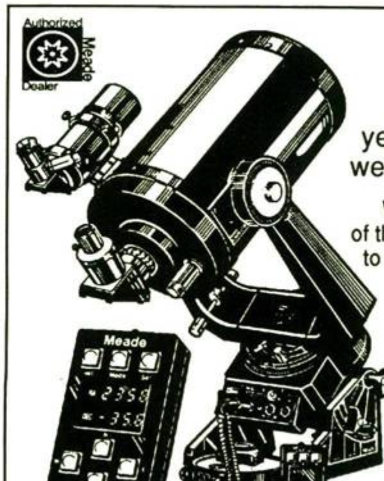

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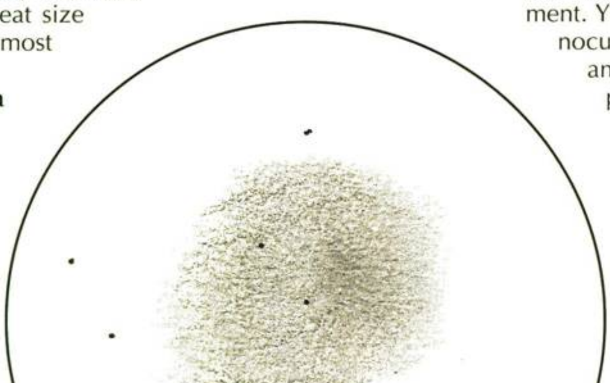
# Tracking Down the Helix

It is king of the planetary nebulae: largest, brightest, and closest. It is also one of the most challenging to observe with a small telescope.

by David Higgins

Planetary nebulae are beloved deep-sky objects. Compact, bright, and colorful, they show details in amateur telescopes both large and small. Their characteristic high surface brightnesses allow observers to see details like rings, central stars, and brightness variations in disks of light from across the Galaxy. Yet not all planetaries are so easy to observe, and this is because of their low surface brightness. Ironically, this includes the king of planetary nebulae, an object that despite its great size and brightness is one of the most challenging objects of all.

**The Helical Nebula** (NGC 7293), so named because its shape resembles that of a double helix, is the closest planetary nebula. (The nebula is also informally called the Helix.) Because it lies only about 450 light-years away, it is also the largest and brightest planetary in the sky. How can such a close, bright, and large object be challenging to view in a small telescope? Surprisingly, its large size is the main culprit. Overall the Helical Nebula equals a magnitude 6.5 star in light output. This total magnitude is a measure of the object's brightness if it were squeezed into a point source. But the Helix measures about 13' across, so its light has a low surface brightness. In other words, it is spread out so much that little parts of it appear very dim. This is the irony of the Helix Nebula and many other deep-sky objects that are large and nebulous.



The Helical Nebula
6-inch f/8 reflector at 70x Sketch by Chesley Runyon, Jr.

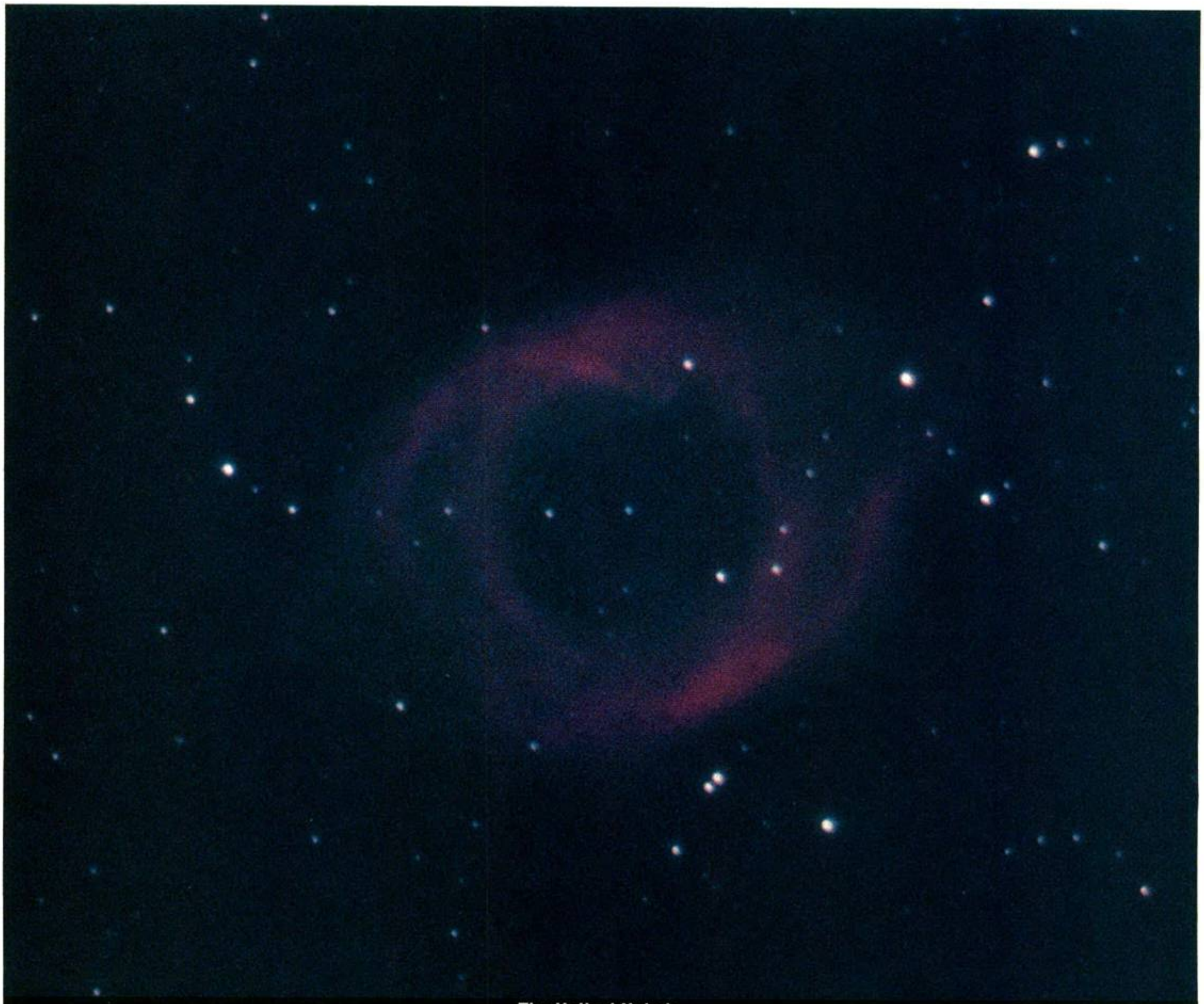
Finding the position of the Helix is easy to do on these crisp fall evenings. Start by aiming your finder scope toward the 3rd-magnitude star Delta Aquarii. Extend a line south to Fomalhaut, the 1st-magnitude star in the constellation Piscis Austrinus. (Although this faint constellation barely peeks over the horizon for most Northern Hemisphere observers, Fomalhaut is bright enough and high enough to be used for star hopping.) Look about halfway between these two stars and about 5° west and you'll see the 5th-magnitude star Upsilon Aquarii. Next, move 1° west and you'll have captured the Helix in a low-power field. But whether or not you can see the Helix depends on several important factors.

The first consideration is the instrument. You can use a pair of large binoculars that offer good contrast and sharp images, but be prepared to steady them with a tripod or by bracing them against your knees. A somewhat better instrument is a rich-field telescope, a short-focus instrument (f/3.5 to f/6) that provides a wide field of view. If you use a normal telescope, be prepared to insert a low-power eyepiece that yields at least a 1° field of view. The idea is to provide yourself with a comfortable amount of dark sky surrounding the nebula so you can see it against the background sky.

Because the Helix culminates low in the sky for most northern observers, attempt to view it only when it lies near the meridian — when it's at the highest possible point in the sky from your viewing location. This minimizes the amount of image-degrading atmosphere you need to look through to see the nebula's image.

A good nebula filter helps tremendously with low-contrast objects like the Helical Nebula. Place it on your low-power eyepiece before attaching it to the telescope and when you arrive at the correct position slowly sweep back and forth in the area. The movement of the ghostly light from the Helix will help your eye detect its presence.

Once you locate the Helical Nebula, what you'll



**The Helical Nebula**
**Mag. 6.5 Size 13' by Jack Newton**

see depends on your telescope and the sky conditions. On exceptionally dark nights, a pair of 7x35 binoculars reveals a faintly glowing donut of light. Small telescopes show a faintly glowing ring of light some 10' across, with a slightly darker center and a 13th-magnitude central star. Larger telescopes will show some detail in the Helix. A 10-inch instrument shows the nebulosity much brighter and the central hole much darker than a 6-inch scope shows. The 10-incher also reveals a sprinkling of stars throughout the nebulosity and several arcs around the edges that appear brighter than most of the rest of the nebula.

In a large backyard scope the view changes considerably with the added light-gathering power. A 17.5-inch scope at 100x provides a memorable view of the Helix. The nebulosity fills the eyepiece field. The southern and eastern edges are visible as the nebula's brightest portions, and the western half contains several faint stars. I get the impression that the nebulosity is very faintly extended north-south, but even with a 17.5-incher I've never been able to directly see the helical coil shape.

The best way to maximize the detail you see is with a specific type of nebula filter. Try a UHC or O III filter and you'll be surprised at just how much you will see. Using the UHC filter with a large backyard scope, the Helix is elongated north and south and appears faintly helical in shape. The central star appears much dimmer, but the central hole is really obvious. The eastern and southern edges are still the brightest, even with the filter. The most obvious feature using the O III filter is the appearance of a faint milky nebulosity within the central hole. The extension of the nebulosity north and south is not visible with the O III so the helical coil is not visible.

After you've finished exploring the Helical Nebula, it's time to turn your gaze toward another planetary nebula in Aquarius. **The Saturn Nebula** (NGC 7009) measures 25" across and shines at 8th magnitude, making it an easy target for small telescope observers. Although this object was discovered in 1782

The Saturn Nebula
Mag. 8.3P Size 25" by Dan Marcus and Bill Smith

M2
Mag. 6.5 Size 12.9' by Bill Iburg

## Deep-Sky Objects in Aquarius

| Object | R.A. (2000.0) | Dec. | Type | Mag. | Size |
|---|---|---|---|---|---|
| M73 | 20h59.0m | -12°38' | OC | $8.9_P$ | 2.8' |
| NGC 7009 | 21h04.2m | -11°22' | PN | $8.3_P$ | 25" |
| M2 | 21h33.5m | -0°49' | GC | 6.5 | 12.9' |
| NGC 7293 | 22h29.6m | -20°48' | PN | $6.5_P$ | 13' |

**Object:** Designation in Messier or NGC catalog. **R.A. and Dec.:** Right ascension and declination in equinox 2000.0. **Type:** GC = globular star cluster, OC = open star cluster, PN = planetary nebula. **Mag.:** V magnitude except subscript P, which denotes photographic magnitude. **Size:** Diameter in arcminutes or arcseconds.

by William Herschel, NGC 7009 was nicknamed the Saturn Nebula half a century later by William Parsons, the Third Earl of Rosse. Parsons noticed what looked like two extensions, or ansae, extending from the ends of the planetary. Because the ansae resembled the rings of Saturn, Parsons created a nickname that stuck.

To find NGC 7009, start by locating the magnitude 4.5 star Nu Aquarii. Simply move 1.5° west and you'll come upon NGC 7009. Because this object is so small (in marked contrast to the Helix), it will appear like a tiny, bright blue disk. A 6-inch scope shows the Saturn Nebula as a pale, blue-green oval that is somewhat elongated east-west. In telescopes 10 inches or more in aperture, the nebula's center is brighter than the disk and the thin, faint extensions are visible on the eastern and western sides.

In large backyard scopes the Saturn Nebula appears appreciably more blue. A 17.5-inch instrument easily shows the nebula's ansae. At high magnifications, the haze surrounding the bright core is somewhat darker on the east side. Try a UHC filter and see what a difference it makes. An O III filter, on the other hand, does not seem to improve the view.

Now move about 2° southwest of NGC 7009 and you'll visit an intriguing Aquarian deep-sky object. **M73** (NGC 6994) is an open cluster that was discovered in 1780 by Charles Messier. This cluster, considered by some astronomers to be only a chance alignment of stars, is quite sparse. In fact it consists of four faint stars arranged in a Y-shaped group. Measuring 2.8' across and glowing at photographic magnitude 8.9, this cluster certainly holds the distinction as the plainest Messier object. Nevertheless, it's a fun object to observe simply so you can later say you've seen it. Messier may have believed he observed nebulosity involved with these stars — something he inferred in his notes — and included the object in his catalog because of it. But all modern studies show only four stars in good old M73, so it remains as one of the great curiosities in deep-sky observing.

If you're a globular cluster fan, then Aquarius does offer another that will provide you with a most impressive view. **M2** (NGC 7089) is another of Messier's objects, but much larger and brighter than M72. Measuring 12.9' across and shining at magnitude 6.5, M2 is easily visible as a round fuzzy ball in most finder scopes. The easiest way to find M2 is by starting with the 3rd-magnitude double star Beta Aquarii. Extend a line about 5° north of Beta and you should have M2 in your finder scope. In 4-inch or smaller scopes, M2 gives the appearance of a fuzzy ball with a sprinkling of stars around the edges.

In 8- to 10-inch scopes, the edges are resolved while a number of stars become visible across the face of the cluster. In medium-sized scopes, the core is brighter than the surrounding haze of the cluster. In large backyard scopes, M2 is an awe-inspiring sight. In large telescopes, beyond the 17.5-inch range, high magnifications show the core as resolved and granular. Although not as large or quite as bright as M13 or M22, M2 is nevertheless a heavyweight among globular clusters and fascinating to observe.

Whether you are fascinated with deep-sky challenges like spotting the Helix, resolving distant globular clusters, or tracking down the star-group M73, Aquarius offers something for you. Couple this with the moderate weather that comes with autumn, and you'll have a combination that can't be beat. ☐

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*David Higgins is a contributing editor of* Deep Sky *magazine and one of the authors of* Stars and Galaxies for Everyone, *a book to be published by AstroMedia next spring.*

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**Galaxies NGC 4631** (left) **and NGC 4656/7** (right) **in Canes Venatici.** 50 minute exposure by Martin Germano using 2415 hypered in a LUMICON Hyper-Kit and an 8" f/5 telescope with a LUMICON 2" Newtonian Easy-Guider. Much detail can be seen in 9th magnitude NGC 4631. Look for nearby 12th magnitude NGC 4627. NGC 4656/7 has an interesting hook; look for the hard-to-see faint extension doubling its length.

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The new LUMICON diagonal mirrors have a special enhanced aluminum coating with a protective overcoating for long life. Visible reflectivity is 94-96% compared to 86-89% for standard aluminum coated mirrors. The extra 5-10% transmission is like adding an inch of aperture! The substrate is fine annealed Pyrex flat to 1/8 wave.

| | | | | | |
|---|---|---|---|---|---|
| 1.32" | **$29.95** | 1.52" | **$34.50** | 1.83" | **$39.50** |
| 2.14" | **$49.50** | 2.60" | **$65.00** | 3.10" | **$89.50** |

## ENHANCED ALUMINUM STAR DIAGONAL

'90° star diagonals with 96% reflectivity enhanced aluminum mirrors in a CNC machined black anodized aluminum body. Performance far exceeds prism diagonals.

| | |
|---|---|
| 1¼" (1.32" mirror) | $99.50 |
| 2" (1.83" mirror)(see photo above) | $159.00 |

## LUMICON FILTERS — BEST IN THE WORLD!

*"The LUMICON OIII proved to be our favorite... It gave the greatest contrast gain."*
*ASTRONOMY February 1991*

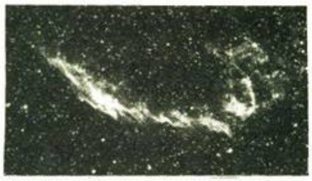
### AMAZING OIII FILTER™

**Helix Nebula, NGC 7293 in Aquarius. Bright and easy with Lumicon Oxygen-III Filter.**

The ultimate in filter performance! The Lumicon Oxygen-III Filter has a contrast twice as high as the high performance Lumicon UHC Filter™. Use the Oxygen-III Filter for observing the very faintest planetary and diffuse emission nebulae. Also gives incredible views of bright nebulae (like M-27, M-17, etc.) from urban locations. Bandpass is 11nm, transmission is 90% for both O-III lines at 496nm and 501nm.

### SEE THE HORSEHEAD!

**Horsehead Nebula in Orion.** This faint nebula is seen best with a LUMICON H-Beta Filter. Photo by J. Marling using a Deep-Sky Filter.



### "I CAN SEE THE VEIL NEBULA!"

Rich Zepernick saw the Veil Nebula for the very first time with a **LUMICON UHC Filter**. He stated, *"It was actually there! and not just around 52 Cygni, but the whole loop! Words cannot possibly express my feelings.I don't know how I managed without these filters."*
**Rich Zepernick, Cresskill, NJ**

### DEEP-SKY FILTER™

### BEST for Astrophotography!

*"Stunning is all I can say,"* says noted astrophotographer Jack Newton. *"Great for BOTH color and black and white photography."*

### BEST WIDE-BAND FILTER!

*"Based on our tests we'd recommend a LUMICON Deep-Sky and Oxygen-III as complimentary filters. The LUMICON Deep-Sky Filter clearly had the best contrast for **reflection** nebulae."*
***Astronomy, Feb. 1991***

| | **Premium*** |
|---|---|
| **0.96" LUMICON DEEP-SKY Filter** threads into most 0.96" eyepieces | $59.50 |
| **1¼" LUMICON DEEP-SKY Filter** threads into most 1¼" eyepieces | $79.50 |
| **48mm LUMICON DEEP-SKY Filter** (1.7" aperture), threads into most 2" eyepieces. Also fits LUMICON EASY-GUIDERS | $119.50 |
| **2" LUMICON DEEP-SKY Filter** (1.5" aperture), threads into most 2" eyepieces. Also has male & female camera T-threads for prime focus photography | $119.50 |
| **72mm LUMICON Giant DEEP-SKY Filter** (62, 67, 77mm adapter, $8) | $299.50 |
| **1¼" LUMICON UHC Filter** threads into most 1¼" eyepieces | $99.50 |
| **48mm LUMICON UHC Filter** (1.75" aperture) fits most 2" eyepieces | $199.50 |
| Set of both premium **DEEP-SKY** and **UHC Filters** (Save 11%) ... 1¼" **$159.50**; 48mm | **$279.50** |
| **LUMICON H-BETA Line Filter** (9mm bandpass at 486nm). For the California Nebula, Horsehead Nebula, and other extremely faint nebulae. **1¼"** .......... **$99.50, 48mm** | $199.50 |
| **Oxygen-III Filter** for very faint planetary and diffuse nebulae, 11nm bandpass at 496nm and 501nm O-III lines ........ **1¼" $99.50, 48mm** | $199.50 |
| Telephoto lens adapter for 2" or 48mm filter. Select 46, 49, 52, 55, 58mm | $6.95 |
| Universal adapter for 1¼" filters. Adapts the 1¼" filters to any 1¼" eyepiece | $16.00 |
| Universal adapter for 48mm or 2" filters. Allows use of any 1¼" eyepiece | $20.00 |

**Premium filters are currently the best in the world. All Lumicon filters include individually measured transmission data.*

# DEEP-SKY ASTROPHOTOGRAPHY

## SR-V 3200 NEW FILM

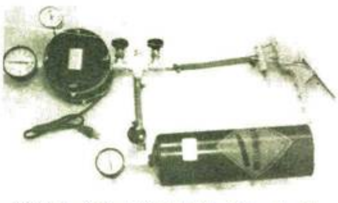
### FILM HYPERSENSITIZATION KITS†

**LUMICON HYPER-KITS™** yield 3-15x film speed gain in long exposures. They are safe & simple to use. Easy HYPER-KIT includes a chamber with all controls and fittings, thermometer, a refillable cylinder of non-flammable forming gas & hand-operated vacuum pump.

U.S. Patent 4,473,636

### MAKE YOUR OWN HYPERED FILM

**MODEL 300 HYPER-KIT** sensitizes any 35mm film in hours. Best for 2415. Achieves highest possible film speeds ..... **$325**



**MODEL 600 HYPER-KIT** (See photo) Like the Model 300, but also sensitizes 120/220 larger format film and small glass plates ..... **$395**

**MODEL 1200 HYPER-KIT** is for 4X5" plates and film up to 5X7". Has 2 gas cylinders and includes temperature controller ... **$595**

Temperature controller for any HYPER-KIT ..... **$65**

Electric Vacuum Pump, Model R-10 **$295**

### GUIDE OFF-AXIS FOR LOVELY ASTROPHOTOS

All **LUMICON EASY-GUIDER™** off-axis guiders† have both radial and 360° rotational adjustments for 5X easier guide-star selection, use 48mm filters, 360° camera rotation, large prisms for bright guide-stars.
*Specify Camera and Telescope type.*
*U.S. Patent 4,448,500*

### NEWTONIAN EASY-GUIDER™

Full aperture. Installs in seconds. Specify 2" or 1¼".

| | |
|---|---|
| NEWTONIAN EASY-GUIDER | **$169.50** |
| 3X Relay Diagonal (see photo) | **$89.50** |
| Illuminated reticle eyepiece system | **$99.50** |

Guider for Hasselblad **$350**, Mamiya 645 **$199**
Pentax 6X7 **add $119**; Pentax 645 **add $139**

### CASSEGRAIN EASY-GUIDER™

For C-8, Meade 2080, Cynamax-8. Includes 50mm achromatic lens for f/5.8 operation—3X shorter exposures! **Superb rich field viewing, too!**

CASSEGRAIN EASY-GUIDER ..... **$225.00**
Adapter for Hasselblad **$198**, Mamiya 645 **$98**
Pentax 6X7 **add $119**; Pentax 645 **add $139**

### GIANT EASY-GUIDER™

For Celestron-11, C-14, and the 10" Meade 2120. Includes 80mm clear aperture achromatic lens for edge-to-edge illumination & pin-point star images. F-ratio adjustable f/4-f/11. **Also yields unmatched Rich-Field viewing.**

GIANT EASY-GUIDER ..... **$395.00**
48mm DEEP-SKY Filter ordered with any EASY-GUIDER (SAVE $20) ..... **add $99.95**
Adapter for Hasselblad **$229**, Mamiya 645**$129**
Pentax 6X7 **add $129**; Pentax 645 **add $149**

### WHAT DO YOU NEED?

1. Illuminated reticle eyepiece ....... **$99.50**
Lumicon 12mm eyepiece system has adjustable LED illumination, dual crosslines, battery pack.

2. Cable release for long exposures .. **$9.95**

3. **LUMICON Quartz Drive Corrector . $219**
Dual-axis drive corrector is essential for astrophotography and/or field use of your telescope. 40Hz/80Hz variable output controls telescope drive. 60Hz Quartz reference ±12VDC Declination control output. Both 110VAC and 12VDC input for home or field use. Declination reverse switch for Newtonians.
**Declination motor (state telescope) .. $99**
**NEW** Deluxe Digital Qtz. Drive Correc. **$298**

**NEW SR-G3200**

### HYPERSENSITIZED FILM

LUMICON Hypersensitized film is essential for good deep-sky astrophotography. Deduct 10% for 3 or more rolls (mixed o.k.).***No C.O.D.s.***

| **Film Type, 35mm** | **Exposures** | **Price** |
|---|---|---|
| 2415, Ultra-fine B&W, red sens. | 36 | $10.95 |
| SR-G3200, fastest of all, color neg | 24 | $13.95 |
| Kodak Ektar 1000 fast, fine grain | 24 | $12.95 |
| Fuji HG400 fine grain color neg. | 12 | $10.95 |
| 3M 1000, fastest slide film | 12 | $12.95 |
| Fujichrome RD100, fine grain slide | 24 | $12.95 |
| D-19 B&W Developer | 1 gal. | $6.95 |

# LUMICON means INNOVATION

LUMICON, 2111 Research Dr., #5, Livermore, CA 94550
(415) 447-9570
FAX (415) 447-9589

## *NEW LOWER PRICES — NEW HIGHER PERFORMANCE — LUMICON® SKY VECTOR™*

### SKY VECTOR™ $399

**LUMICON SKY VECTOR FEATURES:**

- Digital right ascension readout to 1 minute of right ascension (RA)
- Digital decl. readout to 10 arc-min
- 4000 pulse (0.09° accuracy) high resolution encoders
- Polar alignment ***not required!***
- Motor drive ***not required!***
- Just sight two stars to align!
- Works **equally well** for alt-azimuth telescopes like Coulter Odyssey and equatorial mounts like C-8, Meade 2080.
- **No need** to enter latitude, longitude, date, sidereal time, etc.
- 9V Battery lasts many nights.

Each LUMICON SKY VECTOR™ includes one computer with digital readout, two precision high resolution digital shaft encoders, connecting cables, & mounting hardware (for most popular telescopes). **Specify telescope.**

| | |
|---|---|
| **LUMICON SKY VECTOR™** for Meade 2045B, 2080, 2120 *(Specify)* ........ | **$399** |
| For Celestron C-8, C-11 *(Specify)* ... | **$399** |
| For Coulter Odyssey 8", 10", 13", 17½" | **$399** |
| For any alt-azimuth (Dobsonian) scope | **$399** |
| For Celestron C-14 (rewire dec. motor) | **$498** |
| SKY VECTOR KIT (for skilled ATM's) | **$369** |

**Reference catalogues (1000's of objects)**

| | |
|---|---|
| Burnham's *Celestial Handbook*, I, II, III | **$36.85** |
| *Revised New General Catalogue* (all NGC and IC, Epoch 1975.0) .............. | **$35.00** |
| *Sky Catalogue 2000.0*, Vol. II ...... | **$29.95** |

### SKY VECTOR II™ $499

Only the LUMICON SKY VECTOR II has size, **true visual magnitude**, and complete **detailed visual description** for **all** 1500 objects in memory.

OFF ON
DIM
1735+273
RA
DEC
MODE
STAR
UP
DOWN
Sky Vector II™
COMPUTER SETTING CIRCLES
LUMICON®

**LUMICON SKY VECTOR II™ Computer with 1500 object memory, digital readout of coordinates, easy-to-use controls, object size, visual magnitude and detailed visual appearance descriptions.**

*Please specify telescope type:*

| | |
|---|---|
| **LUMICON SKY VECTOR II™** for Meade 2045B, 2080, 2120 (*Please specify)* . | **$499** |
| For Celestron C-8, C-11 *(Specify)* ... | **$499** |
| For Celestron C-14 (rewire dec. motor) | **$575** |
| For Coulter Odyssey 8",10",13"17½" | **$499** |
| For any alt-azimuth (Dobsonian) scope | **$499** |
| SKY VECTOR II (upgrade, computer only) | **$395** |

The **LUMICON SKY VECTOR II™** has all the features of the regular SKY VECTOR, but has 1500 of the best deep-sky objects in memory, selected by noted observer Steve Gottlieb, along with their coordinates, size, true visual magnitude, and complete detailed visual descriptions. The sophisticated computer programming also will guide you to the object selected by displaying the real-time angular separation. Just move the telescope until the angles displayed become "0" using the "GUIDE" mode.

**LUMICON SKY VECTOR II FEATURES:**

- Includes **size, true visual magnitude & detailed visual appearance description** for all 1500 objects
- All 110 Messier objects
- Brightest 31 alignment stars
- User definable catalogue of 25 objects retained in memory
- 703 galaxies, groups & clusters
- 228 best open star clusters
- 170 best planetary nebulae
- 77 emission & reflection nebulae
- 10 best dark nebulae
- 107 best gobular star clusters
- 205 best colored & multiple stars
- Displays Uranometria 2000.0 chart no.
- ROM upgradable for planets, extended object lists, etc.
- TIMER function, elapsed time & stop watch
- 2 star alignment for alt-azimuth or equatorial telescope systems
- 1 star alignment if polar aligned
- Uses Epoch 2000.0 coordinates
- May align on any of the 1500 objects in memory

### NGC SKY VECTOR™ $699

**IMPROVED!**

**1528 Additions / Corrections**

NGC-Sky Vector
OFF ON
DIM
MODE
ENTER
UP
DOWN
LUMICON

**Improved NGC SKY VECTOR with over 8,000 object memory including complete and corrected RNGC catalogue, and IC and planetary catalogues.**

**LUMICON NGC SKY VECTOR FEATURES:**

- All features of LUMICON SKY VECTOR II
- Complete *corrected* RNGC catalogue
- 574 nonexistent NGC objects identified
- 343 corrections to RNGC catalogue
- 203 best colored & multiple stars
- 140 "Best IC Objects" catalogue
- 306 best planetary nebulae selected by Jack Marling in separate catalogue listing
- 268 best "Non NGC / IC" objects catalogued
- "IDENTIFY" program helps you identify an unknown object seen in eyepiece
- "GUIDE" program leads you to object
- Detailed visual or photographic descriptions
- RS-232 port for computer access
- Includes planets ephemeris in computer

| | |
|---|---|
| **LUMICON NGC SKY VECTOR** for Meade 2045, 2080 or 2120 *(Specify)* ........ | **$699** |
| For Celestron C-8, C-11 *(Specify)* ... | **$699** |
| For Celestron C-14 (rewire dec. motor) . | **$775** |
| For Coulter Odyssey 8",10",13",17½" | **$699** |
| For any alt-azimuth telescope ...... | **$699** |
| NGC SKY VECTOR (upgrade, computer only) | **$550** |

# MEADE® TELESCOPES

LUMICON, 2111 Research Dr., #5, Livermore, CA 94550
(415) 447-9570
FAX (415) 447-9589

### NEW PREMIER SERIES TELESCOPES

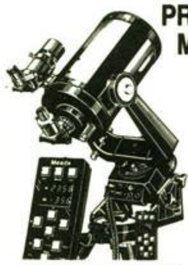
All Meade Premier Series telescopes **include Smart Drive (SD) permanent periodic error correction**, multi-coated enhanced optics (MCOG), Electronic Command Center (ECC), and **include** advanced LX6 all-electronic drive system. Select f/10 or f/6 optics, and select only the optional features you **need.** The 8" has a 6X30 finderscope and the 10" has an 8X50 finderscope. SD = Smart Drive.

| | |
|---|---|
| **2080 Model 40SD,** 8" f/10 ...... | **$1650** |
| **2080 Model 46SD,** 8" f/6 ...... | **$1799** |
| **2080 Model 50SD,** 8" f/10 ...... | **$1950** |
| **2120 Model 40SD,** 10" f/10 .... | **$2150** |
| **2120 Model 46SD,** 10" f/6 ...... | **$2298** |
| **2120 Model 50SD,** 10" f/10 .... | **$2450** |
| **Model 2600** 16" f/10 .......... | **$10,950** |

**Options Enhance Performance**

| | |
|---|---|
| Super Wedge for 10" ....... | **Add $299** |
| #39 Declination motor ...... | **Add $109** |
| Digital setting circle ........ | **Add $399** |
| 2" Star diagonal ........... | **Add $179** |
| LUMICON Cassegrain Easy-Guider *(Please specify camera)* .. | **Add $225** |
| LUMICON Giant Easy-Guider (for #40) *(Specify camera)* | **Add $395** |
| LUMICON Giant Easy-Guider (for #46) *(Specify camera)* | **Add $295** |

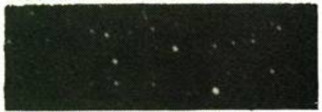
**PREMIER 2080**
**Model 50SD**
**$1950**



**Meade Premier 2080 Model 50SD**

### COMA CORRECTOR

**Coma 1 inch off-axis 17½" f/4.5**



**Same field with LUMICON coma corrector; smaller, more numerous stars.**

This computer-designed LUMICON 2" lens reduces coma and flattens the field for both viewing and photography. It threads into LUMICON 2" EASY-GUIDERS for effortless installation. This lens is optimized for f/4.5 and reduces aberrations for f/3.5 to f/5 Newtonians. Off-axis images are much smaller, making off-axis guiding far easier and yielding round pinpoint star images in photos. Since star images are sharp over a full 2¼" circle, you can use medium format cameras in addition to 35mm cameras. This zero power lens does not change image scale nor shift focus, and all lens surfaces are multi-coated for highest efficiency. Although designed for photography you may also use this lens to improve image quality in wide-field viewing with low power eyepieces. Clear aperture = 1.8".

| | |
|---|---|
| LUMICON Coma Corrector/Field Flattener Lens ...................... | **$285.00** |
| LUMICON 2" EASY-GUIDER . | **$169.50** |
| 2" EASY-GUIDER (Mamiya 645) | **$199.50** |
| 2" Adapter for Pentax 6x7 .... | **$85.00** |
| 2" Adapter for Hasselblad . | **$185.00** |
| 2" Adapter for Bronica SQ-A | **$175.00** |
| 2" Extension for viewing ... | **$26.00** |

# LUMICON ACCESSORIES

### 2" DELUXE BARLOW

**1.8x Multiplier Lens**

The computer-designed LUMICON 2" Multiplier/Field Flattener multiplies the image scale in photography by 1.8x (f/4.5 becomes f/8). Use it with any LUMICON 2" EASY-GUIDER. Guide-stars also become much sharper to make guiding easier. This lens is optimized for f/4.5, but will work well with any optical system. It may also be used visually as a highly corrected 2" Barlow lens.

| | |
|---|---|
| LUMICON 1.8x Multiplier Lens ... | **$235.00** |

### NEW! LOW PROFILE HELICAL FOCUSERS

**FROM**
**$59.50**

**LUMICON® LOW PROFILE FOCUSERS**

LUMICON now offers 3 different low-profile helical focusers. They stand only 1¼-1½" above the telescope tube. Use the 1¼" or 2" versions for viewing. Use the 2" non-rotating focuser for convenient photography with the LUMICON 2" EASY-GUIDER™.

**Select your desired base-plate shape!** Flat, 7" OD, 9½" OD, 12½" OD, 16" OD, 21" OD.

| | |
|---|---|
| **LUMICON 1¼" Helical Focuser** ..... | **$59.50** |
| **LUMICON 2" Helical Focuser** 1½" high | **$65.00** |
| **LUMICON Non-rotating Helical Focuser** | **$89.50** |
| 2" rack & pinion focuser, only 2" high | **$139.00** |
| 3 handles for non-rotating focuser .... | **$12.95** |
| 2"/1¼" **adapter** w/48mm filter threads | **$20.00** |
| **2" LUMICON EASY-GUIDER** .... | **$169.50** |

### LUMICON 50mm, 80mm SUPER-FINDER™

Visual Astronomers prefer the LUMICON 80mm SUPER-FINDER™, since hundreds of deep-sky objects, including most Messier objects, are visible directly. SUPER-FINDERS also make nice small portable telescopes. 80mm aperture, F=300mm coated achromat or 50mm, F=200mm coated achromat. Eyepieces and/or star diagonal are extra.

| | |
|---|---|
| 1¼" 50mm Finderscope **$59.50**, right-angle | **$89.50** |
| 1¼" straight-thru 80mm SUPER-FINDER .... | **$169** |
| 1¼" right-angle 80mm SUPER-FINDER .. | **$179.50** |
| 1¼" right-angle version, w/star diagonal .... | **$209** |
| 25mm Cross-hair 1¼" eyepiece (12X) ....... | **$39** |
| 1¼" Star Diagonal **$39**, Mounting Brackets, | **$37** |
| 1¼" Amici Prism diag. for correct left-right views | **$69.50** |

### 2" ADAPTERS MEADE, CELESTRON TELESCOPES

These adapters convert refractors and Schmidt-Cassegrain telescopes for 2" operation. They allow use of 2" accessories, such as the LUMICON 2" EASY-GUIDER for photography. They also allow use of 2" eyepieces and/or 2" star diagonal for viewing.

| | |
|---|---|
| 2" adapter for C-8, Meade 2080, etc.... | **$26.00** |
| 2" adapter for C-80, C-100 refractor ... | **$39.50** |
| 2" adapter for C-70, C-80F, C-90F, C-100F | **$39.50** |
| 2" Accessory adapter for Comet Catcher, C-6, Meade 312, 321 refractor ........... | **$30.00** |
| 2" LUMICON EASY-GUIDER (state camera) | **$169.50** |

ODYSSEY
TELESCOPES
Seeing the *real* Universe

FREE INFORMATION
- ODYSSEY GUIDE
- OWNER COMMENTS
- REPRINTS
- DOBSONIAN INFO.
- COULTER OPTICAL NEWS
- PRODUCT LIST

ASK FOR IT!

8 inch $275.00

"On the Moon and Jupiter, the Odyssey 8 showed as much detail as several 8" Schmidt-Cassegrains nearby."
David McGough, Millington, N.J.

"It is worth twice what I paid, but please don't raise the price. I want to get my son one in a few years."
Tom Johnston, Boulder, Colo.

10.1 inch $345.00

"Careful star-testing of the 10.1" Odyssey Compact I received last March and of the 10.1" my neighbor Doug Barnes picked up in mid-October suggests a high level of quality control which is astonishing. Diffraction patterns are virtually interchangeable, and both scopes show textbook optical results (both in-focus and out-of-focus)."
Lee Johnson, Coquitlam, B.C. Canada

13.1 inch $575.00

"In amateur astronomy for over 35 years and I have seen my share of all kinds of telescopes, good and bad. To say the least, the Odyssey 1 outperforms any thing that I have seen!!"
Richard Ziegler, Maumee, Ohio

"There is not another telescope of equal size in our club that can touch the clear image and ease of operation that Odyssey 1 provides."
Mark Davenport, Pinellas Park, Fla.

17.5 inch $1150.00

"I've only had a chance to view once so far, but am thoroughly thrilled with it. Viewing from a (Santa Barbara, Ca.) residential front yard, the Orion Nebula was indeed a treat – reddish tinges on the predominating green, with many subtle wisps and lanes very clear. The Andromeda Galaxy was surprisingly bright, as was its companion." David Broad, Santa Barbara, Ca.

Lightweight Mirror Optics at Low, Low Prices:
Aluminized & overcoated

| | |
|---|---|
| 10 inch f/5.6 | $150.00 |
| 10.1 inch f/4.5 | $155.00 |
| 12.5 inch f/6 | $287.50 |
| 13.1 inch f/4.5 | $295.00 |
| 17.5 inch f/4.5 | $675.00 |

Elliptical Diagonals

| | |
|---|---|
| 1.83" — $17.95 | 3.10" — $ 39.95 |
| 2.14" — $21.95 | 4.25" — $ 79.95 |
| 2.60" — $25.95 | 6.25" — $200.00 |

EASY TO ORDER . . . Phone or mail your order in today. Visa/MasterCard accepted. All telescopes are shipped freight charges collect. All mirrors are shipped prepaid in the contiguous U.S.A. No sales tax on out-of-state orders. Phone orders Mon-Fri 8 am-4:30 pm local time. Call 1-714- 659-4621

- 30 days returnable
- 30 days exchangeable
- 2 years materials and workmanship

Coulter Optical, Inc.
P.O. Box K
Idyllwild, CA 92349-1107
"OPTIMUM OPTICS AT MINIMUM COST SINCE 1967"

# AN INTERPLANETARY WATCH

**CASIO Cosmo Phase Watch**, *Model 830. CASIO U.S.A. $49.95. Available in many department stores and from many advertisers in ASTRONOMY magazine.*

The Cosmo Phase is one of two astronomically oriented wrist watches produced by CASIO. This one features an electronic orrery, or map of the solar system, that shows the position of all nine planets and Comet Halley in reference to the Sun. The other model, the Moon Graph (not reviewed), features a display of moon phases.

In the Cosmo Phase, the top of the watch displays the current position of the planets and Halley as seen from about 45 degrees above the plane of the ecliptic. The lower half of the watch is used to display the time, day, month, year, and the day of the week. As with many other digital watches, the Cosmo Phase has several other functions, including an alarm and a stopwatch. It can also display either 12- or 24-hour time. It is claimed to be waterproof and is rated to withstand a depth of 100 meters. Not being a scuba diver, I did not test this claim. Being an astronomer, I concentrated instead on the effectiveness of the liquid-crystal display of the planet positions.

The orrery display is inside a 3/8-inch high by 7/8-inch wide oval. The Sun is located at the center of the oval with ten permanently displayed circles representing the orbits of the planets and Halley. Pluto, Neptune, Uranus, Mars, Venus, and Mercury are shown as small, black dots. Earth is represented as a larger, open circle, Jupiter as a large open circle with two black bands going across its face, and Saturn as a small, solid black dot with a line representing the rings. Halley is another black circle with two short lines representing the comet's tail. Once you become familiar with the symbols, it is easy to tell one planet from another — with the exception of Venus and Mercury. If these two planets are located near one another, determining which planet is which can be difficult because the orbits of the two inner planets at such a small scale are almost in contact.

A useful feature is the ability to set the orrery to any date between the years 1901 and 2200. With it you can show the locations of planets past, present, and future. This is a great capability to have on your wrist — while looking at an early evening photo of several planets I had taken in 1984, I was able to use the watch to figure out which planets were in the frame, without having to refer to a handbook or computer program, neither of which were handy.

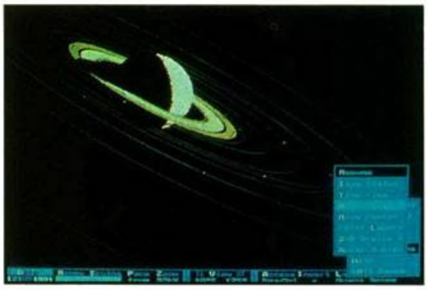
Another function many amateur astronomers might find valuable is the dating of past and future solar eclipses. The Cosmo Phase provides these dates within its 299-year period.

A not-so-great feature is the location of Comet Halley. This would have made the watch a big seller back in 1985, but with interest in Halley gone the way of the comet, the Halley display simply makes for more clutter.

In the six months I've owned the watch, I have had no problems with it. It has stood up well to everyday use. The band shows no sign of tearing and the crystal has withstood minor abrasions without scratching.

I found the CASIO Cosmo Phase watch to be a lot of fun. Yes, it is a novelty, but it can also be useful, if only as a unique conversation piece with both astronomical and non-astronomical friends.

— *Robert Bunge*



**DANCE OF THE PLANETS** operates from pop-up menus, accessible either via the keyboard or through a mouse.

## SOFTWARE UPDATES

**Dance of the Planets Version 2.3**, *A.R.C. Science Simulation Software, P.O. Box 1974, Loveland, CO 80539-1974, (800) 759-1642, FAX: (303) 667-1105. $195. Requires IBM-AT or compatible with 640K RAM, EGA or VGA graphics, and DOS 3.x. Hard disk and math coprocessor recommended.*

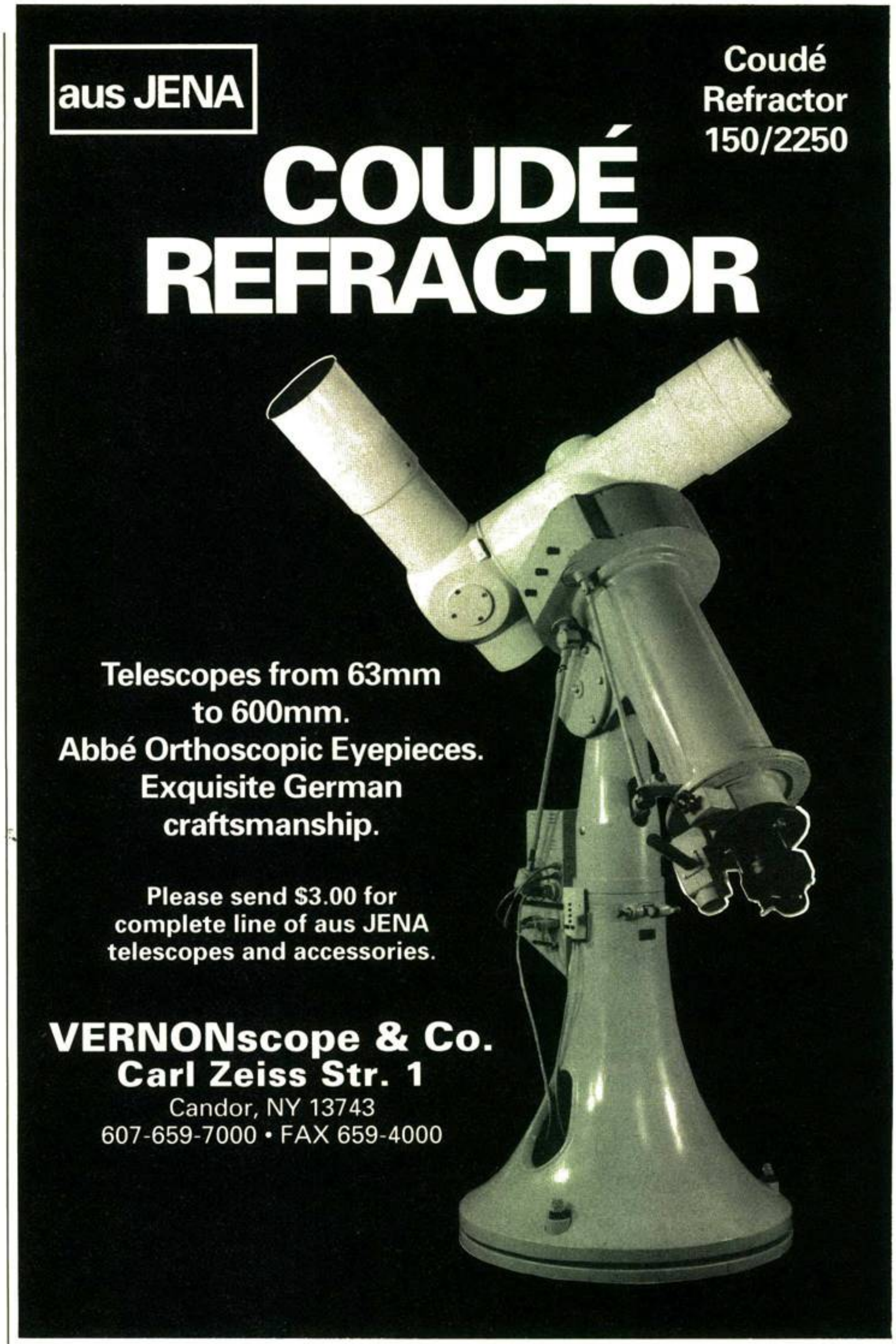
The latest version, numbered 2.3, of this popular simulation program adds graphic details to its depiction of solar eclipses, including the addition of the solar corona and stars appearing during totality. Users can add local horizons and the earliest date for viewing the sky has been extended back to 4681 BC. Version 2.3 also takes into account the slowing of Earth's rotation, making simulation of ancient eclipses all the more accurate.

Dance of the Planets currently features 9,100 stars and 1,300 deep-sky objects, along with all nine planets, 61 of their moons, and over 4,650 asteroids and 1,300 comets. Up to 20 comets or asteroids can be active on the screen at one time. Dance's accurate simulation of the gravitational interaction of solar system bodies allows you to view, for example, how Jupiter affects the orbits of comets or how Saturn's co-orbital satellites swap orbits. The graphic displays are superb, making this one of the finest astronomical programs for the PC. For a review of version 1.3, see the April 1990 ASTRONOMY.

**Distant Suns 4.0**, *Virtual Reality Laboratories, Inc., 2341 Ganador Court, San Luis Obispo, CA 93401, (805) 545-8515. $99.95. Upgrade from Version 3.0: $30, Upgrade from Galileo: $45. Requires at least an Amiga 500 with minimum of 1 megabyte of RAM , two floppy disk drives, and AmigaDOS 1.3 or higher. Hard drive recommended.*

Distant Suns is a greatly expanded and improved version of a program originally released in 1987 called Galileo. It remains the only general-purpose astronomical program for Amiga computers that we know of. This latest version expands the stellar database from 2,200 to 4,200 stars, with expansion disks increasing the database to 255,000 stars, a database size requiring 25 megabytes of hard disk space. Version 4.0 also provides the ability to set up vantage points as far as 400 astronomical units from the Sun, to enter user-defined objects such as new comets or asteroids, and to save and restore user-defined sky configurations. Version 4.0 also has a movable control panel, bit-mapped images of the Sun and Moon, a user-defined horizon, and more legible screen fonts. The new version also displays full screen images of selected celestial objects. These can be ones supplied by the manufacturer or ones you load in yourself.

If you are an Amiga fan looking for astronomy software, Distant Suns is the only choice at the moment, but a good choice — it has an impressive array of capabilities and makes full use of the Amiga's excellent display capabilities. But it will soon have some competition — an Amiga version of Voyager, the hit program for Macintosh computers, is promised from Carina Software. ☐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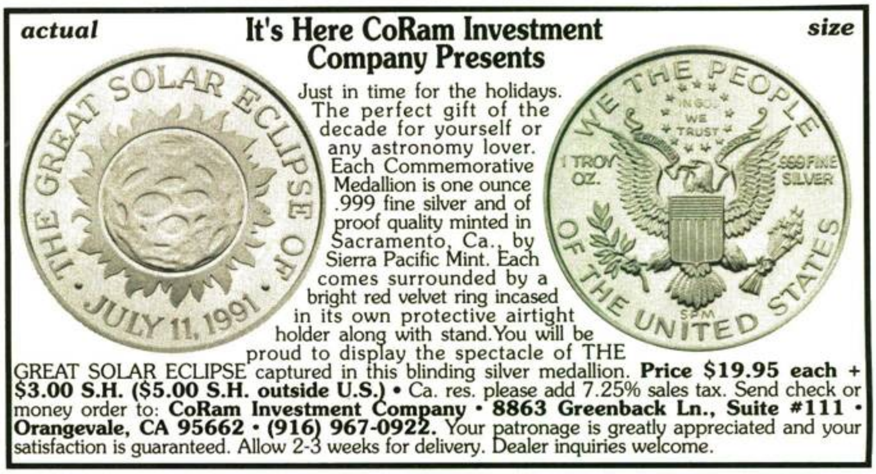
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# A FINE GUIDE TO VARIABLE STARS

*Variable Stars,* by John E. Isles, (Enslow Publishers, 1990), ISBN 0-89490-208-3, softcover, 195 pages, $19.95.

Volume 8 of the Webb Society's Deep Sky Observing Manual series is devoted to variable stars. (Previous volumes have dealt with subjects such as double stars, nebulae, clusters, and galaxies.) Isles' book tells you not only where to find variable stars, but what you are observing, and how to make useful records of your observations. He covers stars in both the northern and the southern sky, and the book is quite up-to-date, for he discusses even the slow decline in brightness of supernova 1987A.

Variables are stars that exhibit a change in brightness. This variability may range from a fraction of a magnitude to many magnitudes and can occur on time scales measurable in minutes, days, months, or even years, depending on the object. Most of the stars in the book can be tracked by eye, with the naked eye, binoculars, or a telescope.

Of course, anyone can view variables in a casual way, but the real enjoyment comes when observers view a little more systematically. This book intends, first, to get telescope owners interested in observing variables and, second, to help them to record the brightness changes the stars undergo. Variable stars come in six main kinds: eruptive, pulsating, rotating, cataclysmic, eclipsing, and x-ray. Each of these classes contains several subtypes, which Isles details in an easy-to-understand manner. The text is supplemented with finder charts and light curves (plots of brightness versus time) by John Lewis.

The author points out that observing variables is "one of the few fields of scientific research where useful work can be done by the amateur with limited training and equipment." The chapter on observing techniques tells you the steps to take to become a good variable star observer. The chapter also contains a table of 24 stars you can follow with the naked eye and another table of 10 stars which at times become visible to the naked eye. The main point Isles makes is that fancy equipment is much less important than consistency and developing a routine for regular observations.

The second half of the book contains a field guide to 110 variables for amateurs to observe. Some of the stars are easy binocular targets (like RZ and SU Cassiopeiae); others are harder to find. Detailed information about each of the stars is accompanied by a finder chart. The guide tells you how hard it is to find the target star, what to look for, what type of variable it is and, for some stars, its place in astronomical history.

This book cuts cleanly through a lot of astrophysical jargon to present its information in a manner easy to grasp. It is an ideal item for any observer's library. *Robert Garfinkle*

### Observing

*A Portfolio of Lunar Drawings,* by Harold Hill, (Cambridge University Press, 1991), ISBN 0-521-38113-4, 240 pages, sewn binding, hardcover, $49.50.

As the title suggests, this is not a lunar atlas but a collection of excellent drawings by Hill, a British amateur, of 95 regions on the Moon. By intent these avoid such well-studied features as Copernicus, Aristarchus, and Plato and instead deal with lesser-known regions such as the Ariadaeus Rille, Taruntius, and Wargentin. The drawings (in pen, ink, and wash) are reproduced very clearly and are accompanied by a text that gives lots of observing details on each feature.

*Astronomy Activity Book,* by Dennis Schatz, (Little Simon, 1991), ISBN 0-671-70449-4, 48 pages, paperback, $6.95.

As the author says, this book is aimed at kids 10 years and older — like up to 60, maybe? This is an excellent introduction to astronomy that uses very simple do-it-yourself exercises to make clear the basic subjects in astronomy — such as constellations, lunar phases, eclipses, and the like. It is illustrated by famed cartoonist Ray ("The Wordless Workshop") Doty and includes a cut-out cardboard planisphere, or star-wheel.

### Myth and History

*Beyond the Blue Horizon,* by E. C. Krupp, (HarperCollins, 1991), ISBN 0-06-015653-8, 387 pages, hardcover, $35.00.

*This* is a detailed yet readable look at the world's myths and legends relating to the Sun, Moon, planets, and stars. It contains lots of illustrations and a 30-page, double-column bibliography for enthusiasts who wish to probe further.

*The Lord of Uraniborg,* by Victor E. Thoren, (Cambridge University Press, 1991), ISBN 0-521-35158-8, 523 pages, sewn binding, hardcover, $59.50.

Anyone who thinks "swashbuckling astronomer" is a contradiction should read the life of Tycho Brahe. As Thoren's scholarly yet enjoyable biography shows, this 16th-century Danish nobleman astronomer was a colorful character — and a highly competent observer who amassed an unparalleled series of observations of planet positions. After Tycho's death, these gave his former assistant Johannes Kepler the necessary data from which to construct the first laws of planetary motion.

### Astronomical Science

*Third Reference Catalogue of Bright Galaxies,* by Gérard de Vaucouleurs *et al.,* (Springer-Verlag, 1991), ISBN 0-387-97549-7, 1069 pages in three volumes, acid-free paper, sewn binding, hardcover, 1991, $237.00.

The RC3 (in astronomers' shorthand) contains listings of 23,024 galaxies brighter than magnitude 15.5 and spanning at least a second of arc in apparent size. Volume 1 contains the explanations, references to the published literature, and appendices, while volumes 2 and 3 contain the catalogue proper.

*Light Pollution, Radio Interference, and Space Debris,* edited by David L. Crawford, (Astronomical Society of the Pacific, 1991), ISBN 0-937797-36-8, 331 pages, sewn binding, hardcover, $32.00.

This readable anthology is a collection of papers given at an IAU colloquium in August 1989 which dealt with environmental matters of urgent concern to both amateur and professional astronomers.

*Exploring the Sun; Solar Science Since Galileo,* by Karl Hufbauer, (Johns Hopkins, 1991), ISBN 0-8018-4098-8, 370 pages, acid-free paper, sewn binding, hardcover, $39.95.

The story of solar science since Galileo is one of the growing realization by scientists that the Sun was a star, followed by the subsequent development of tools to study it and the physical understanding to make sense of it. Hufbauer concludes his story with the re-entry of the Solar Maximum Mission satellite in 1989. □

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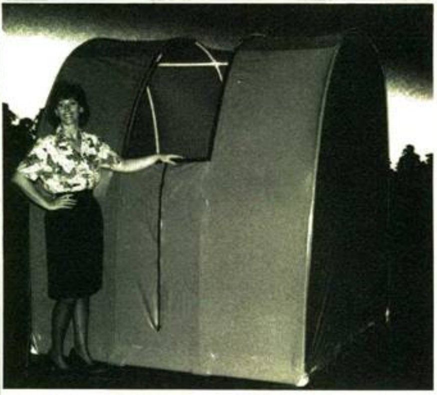

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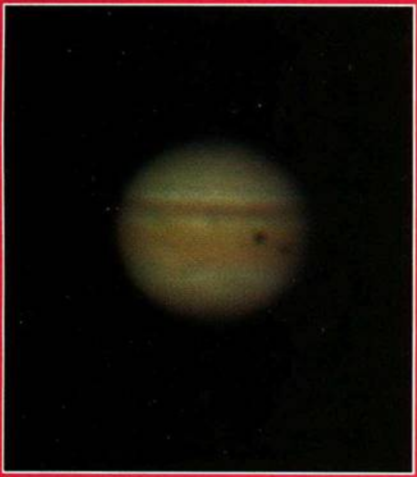
# THE GLOWING SKY OF JUNE

**A MULTICOLORED LIGHT SHOW** danced across the sky in June as a series of impressive aurorae dominated backyard viewing for more than two weeks. Photos of aurorae on June 10 by Peter Chan (above) and Robert Miller (below).

"I was patrolling galaxies in Canes Venatici as part of a supernova patrol when I noticed a bright, greenish glow along the northwestern, northern, and northeastern horizons." We heard many similar stories from readers who contacted us with accounts, photos, or drawings related to a large outbreak of auroral activity that occured in June 1991. Myron E. Wasiuta's story of his supernova search disrupted by the intensely active storm on June 4-5 is nicely representative of many such observations.

"I was observing from our club's dark-sky site near Calverton, Virginia," says Wasiuta. "The glow was initially very diffuse and extended one-quarter of the way up to the zenith. A few small, patchy clouds lay in front of the aurora, and they appeared quite dark against the gray-green backdrop. A few minutes later, five or six bright green rays extended and arced up nearly to the zenith. Somewhat later, a bright red pillar appeared. I estimated its extent at about 5° wide and 20° high. This was one of the highlights of the display — the beautiful, contrasting reds and greens were breathtaking!"

From my own back yard south of Waukesha, Wisconsin, I saw three spectacular nights' worth of aurorae beginning on the evening of June 10. The show began about 10:30 p.m. each evening with an anomalously bright glow low in the north, northeast, and northwest. By the time the clock struck 11:00 p.m., an extensive curtain of greenish-white light hung over the northern sky, nearly to the zenith, with five or six, and sometimes more, sharply defined spikes extending vertically from the horizon upward. I didn't see any reddish colors and thought the aurora was somewhat slow to change form. But it was terrifically bright and constituted the most dramatic display of auroral activity since the spring of 1989. As I recalled the structure in the latest auroral activity, Myron Wasiuta's excitement rang through my head. "I will long remember this night," he says. "After all, it was my first aurora!" You've got great ability to choose them, Myron. — *David J. Eicher*



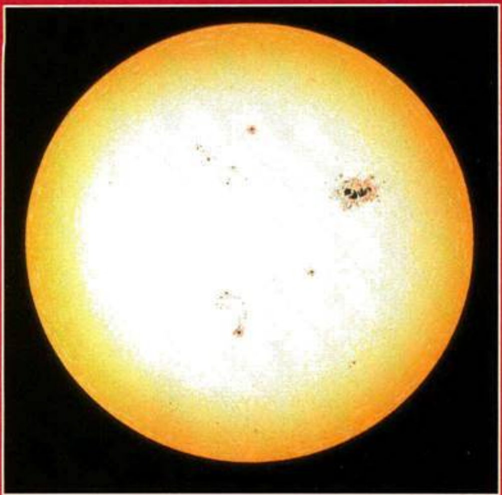
# "A FLICKERING, SHIMMERING SPECTACLE!"

In early June 1991, a succession of solar storms erupted and created an extended show of bright aurorae over the northern and southern poles of Earth. Kevin Milani's fisheye lens photo of the June 10 aurora (opposite page, top) wins this month's $100 "Best Astrophoto" award. Many observers wrote us with their impressions of the auroral activity. One astronomer called it "a flickering, shimmering spectacle, the likes of which I've never seen."

Cameras and sketch pads recorded impressions of the cause of the great aurorae. Don Trombino's hydrogen-alpha photo taken on June 10 shows the tremendously powerful flare that caused the activity (opposite page, bottom right). Trombino used a 6-inch refractor at f/30, Tech Pan film, and a 1/125-second exposure. Two days before Trombino's effort, Edwin Faughn painted the solar disk's large sunspot groups (opposite page, bottom left). Faughn made the sketch with an 8-inch f/10 SCT at 80x.

In the early evening skies of June, before the aurorae reached their peaks, skygazers were busy watching a triple conjunction involving Venus, Jupiter, and Mars. Jeffrey L. Jones' photo made on June 15 shows the three planets in a tight triangle alongside the overexposed Moon (below left). Back on May 8 Stephen Keene used the 31-inch f/7 telescope at Warren Rupp Observatory in Ohio to capture Jupiter spotted by a shadow transit of Ganymede and a transit of Callisto (upper left).

Great stirrings of activity came from deep-sky observers recording the fading light of supernovae in distant galaxies. On May 12, Kim Zussman recorded Supernova 1991T in NGC 4527 as the supernova glowed at about magnitude 12.5 (below). Four nights later, Ronald E. Royer captured 14th-magnitude Supernova 1991X in the galaxy NGC 4902 (bottom).



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ASTRONOMY

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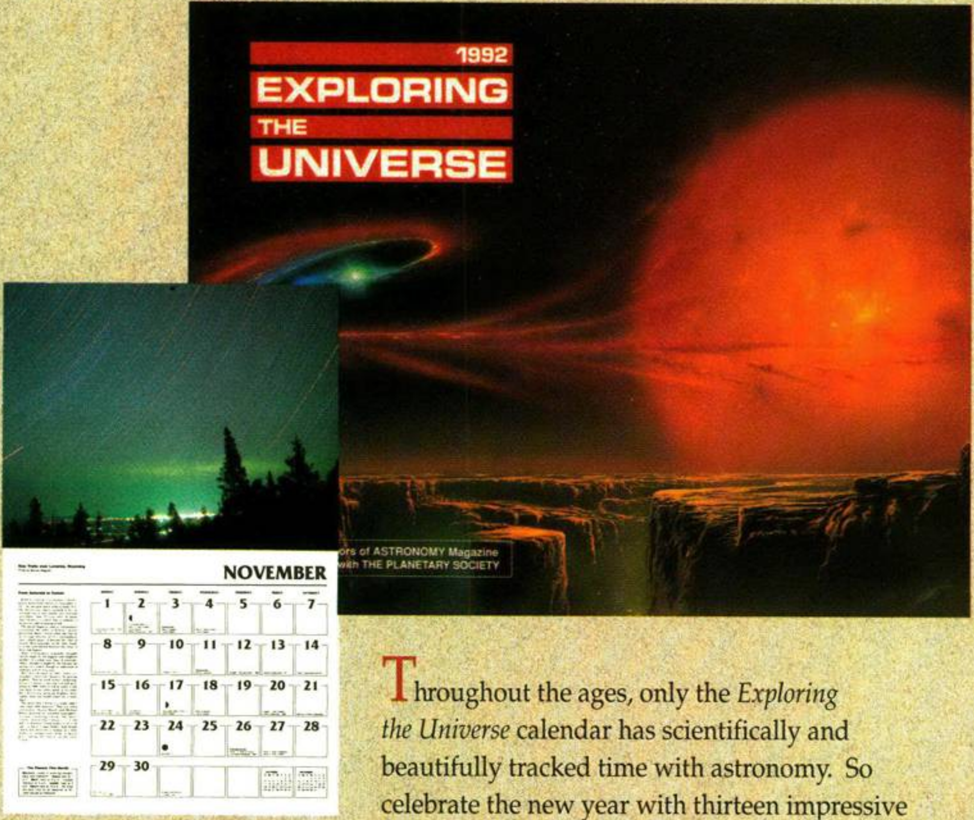
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*Tele Vue Optics, Inc., 20 Dexter Plaza, Pearl River, NY 10965, (914) 735-4044, FAX: (914) 735-4112. Solaris (without T-Scanner): $1,995.*

## 2 Planetarium Plans

Plans for Star Hut, an inflatable, planetarium dome 18 feet in diameter are available from Living Originals. The completed dome is inexpensive to build, stands 12 feet high, and will accommodate 35 children.

*Living Originals, Star Hut, P.O. Box 157, Wentzville, MO 63385. Plans: $8.95.*

## 3 High-Resolution CCD Camera

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*ELECTRIM Corporation, P.O. Box 2074, Princeton, NJ 08543, (609) 683-5546, FAX: (609) 683-5882. $850.*

*This department presents new product announcements issued by their manufacturers. The product information is as supplied by the manufacturers or distributors. All prices are suggested retail. Suppliers are invited to send their product announcements to the attention of Alan Dyer.*

### 4 Solar System Model

This teaching aid is a 45- by 18-inch raised relief plastic model of all the planets in the solar system. The planets are depicted in color and are shown with their diameters to correct relative scale.

*Black Forest Observatory, 12815 Porcupine Lane, Colorado Springs, CO 80908, (719) 495-3828. $149.95 postage paid in the contiguous U.S. Call for shipping costs to Alaska, Hawaii, and Canada.*

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*AMECO Engineering and Manufacturing, P.O. Box 1719, Poulsbo, WA 98370-1719, (206) 297-4456. Regular model: $49.95, Patio model: $69.95.*

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*Flytech Technology (USA), 3008 Scott Boulevard, Santa Clara, CA 95054, (408) 727-7373. Prices range from under $400 (complete XT-type system) to about $3,000 for a 386SX SuperVGA system with 4 MB of RAM and 80 MB hard drive.*

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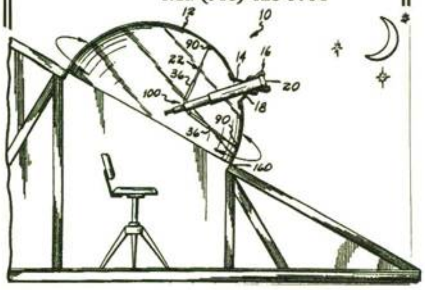

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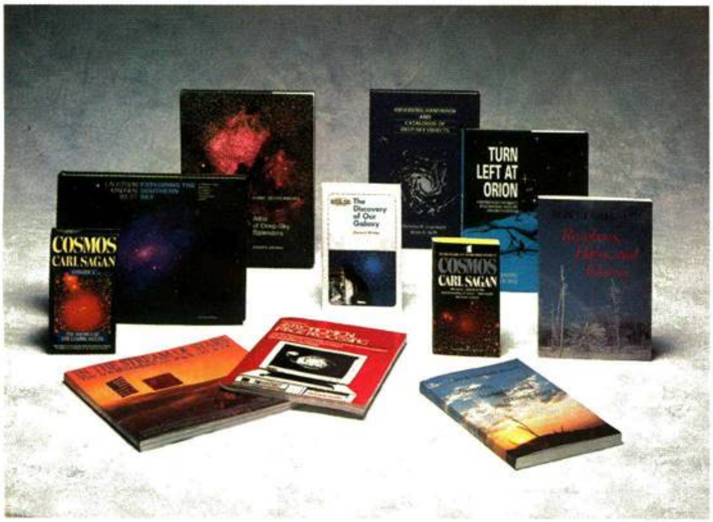

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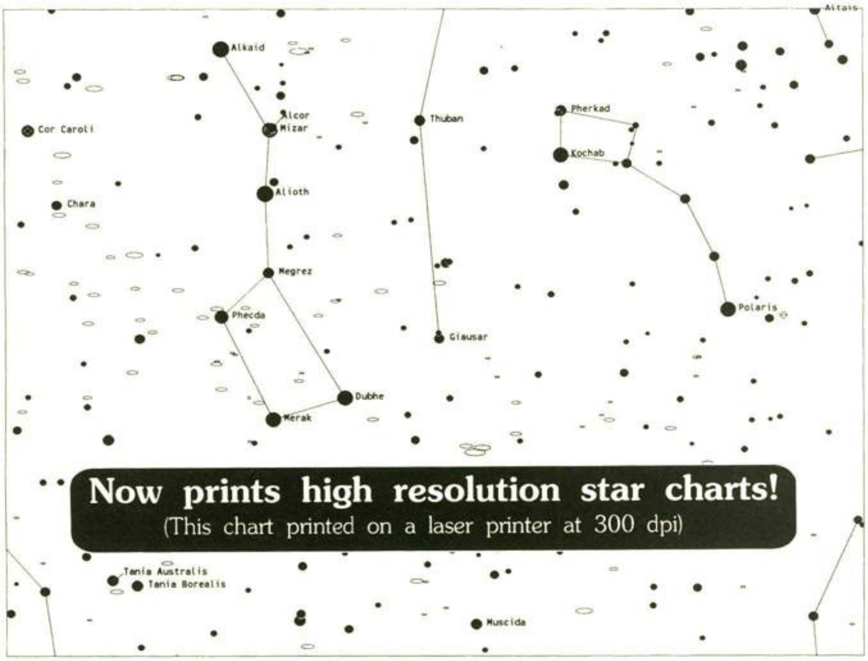

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**8th Annual Okie-Tex Star Party**, Lake Murray State Park, near Ardmore, Oklahoma. Sponsored by the Oklahoma City Astronomy Club. Contact: Oklahoma City Astronomy Club, 6616 N.W. 20th, Bethany, OK 73008.

**October 3-6**
**Georgia Star Party**, Hard Labor Creek Observatory, near Atlanta, Georgia. Sponsored by the Astronomical Society of the Atlantic. Contact: Astronomical Society of the Atlantic, c/o Center for High Angular Resolution Astronomy, Georgia State University, Atlanta, GA 30303. Phone: (404) 264-0451.

**October 3-6**
**Planetarium Association of Canada Biennial Conference**, Toronto, Canada. Contact: Ian McGregor, McLaughlin Planetarium, 100 Queen's Park Crescent, Toronto, Ontario, Canada M5S 2C6. Phone: (416) 586-5743.

**October 4-5**
**All Arizona Star Party**. Sponsored by the Tucson Amateur Astronomy Association. Contact: Tucson Amateur Astronomy Association, 70 West Forrest Feezor, Tucson, AZ 85747.

**October 4-5**
**AstroAssembly**, Seagrave Memorial Observatory, North Scituate, Rhode Island. Sponsored by Skyscrapers, Inc. Contact: Conrad Cardano, 68 Colvintown Road, Coventry, RI 02816. Phone: (401) 828-0702 (evenings).

**October 4-5**
**9th Annual Northern Virginia Telescope Meet**, C. M. Crockett Park, Calverton, Virginia. Contact: Al Schumann, 6121 Rivanna Drive, Springfield, VA 22150. Phone: (703) 256-8359.

**October 4-6**
**13th Annual Astronomy Jamboree**, Southold, New York. Sponsored by the Custer Institute. Contact: Custer Institute, Main Bayview Road, P. O. Box 1204, Southold, NY 11971. Phone: (516) 765-2626.

**October 4-6**
**Eastern Iowa Star Party**. Contact: Quad Cities Astronomical Society, P. O. Box 3706, Davenport, IA 52806.

**October 4-6**
**Stella-Della-Valley**, Ottsville, Pennsylvania. Sponsored by the Bucks-Mont Astronomical Association. Contact: Ed

Melnick, 1443 Devon Road, Warminster, PA 18974. Phone: (215) 443-7929.

**October 4-6**
**3rd Annual Astronomy Workshop**, Camp Maskapatoon, Alberta. Sponsored by the Edmonton Centre of the Royal Astronomical Society of Canada. Contact: Astronomy Workshop, 8950 Windsor Road, Edmonton, Alberta, Canada T6G 2A2. Phone: Russ Sampson, (403) 439-3474.

**October 5**
**7th Annual Blue Ridge Parkway Regional Stargaze**, Julian Price Park, near Blowing Rock, North Carolina. Contact: Greg Kirby, Route 3, Box 472, Granite Falls, NC 28630. Phone: (704) 396-7656.

**October 11-12**
**Twin Lakes Star Party**. Sponsored by the West Kentucky Amateur Astronomers. Contact: Jim Boren, Land between the Lakes, Golden Pond, KY 42211-9001. Phone: (615) 232-7405 (days), (615) 232-6820 (evenings).

**October 11-13** (note change of date)
**Connecticut Star Party**, Colebrook, Connecticut. Sponsored by the Astronomical Society of New Haven. Contact: Astronomical Society of New Haven, P. O. Box 3005, New Haven, CT 06515.

**October 12**
**Starfest '91**. Contact: Bays Mountain Amateur Astronomers, 853 Bays Mountain Park Road, Kingsport, TN 37663.

**October 16-19**
**27th Annual Conference of the Great Lakes Planetarium Association**, Youngstown State University, Youngstown, Ohio. Contact: Warren Young, Ward Beecher Planetarium, Youngstown State University, Youngstown, OH 44555. Phone: (216) 742-3616.

**October 18-20**
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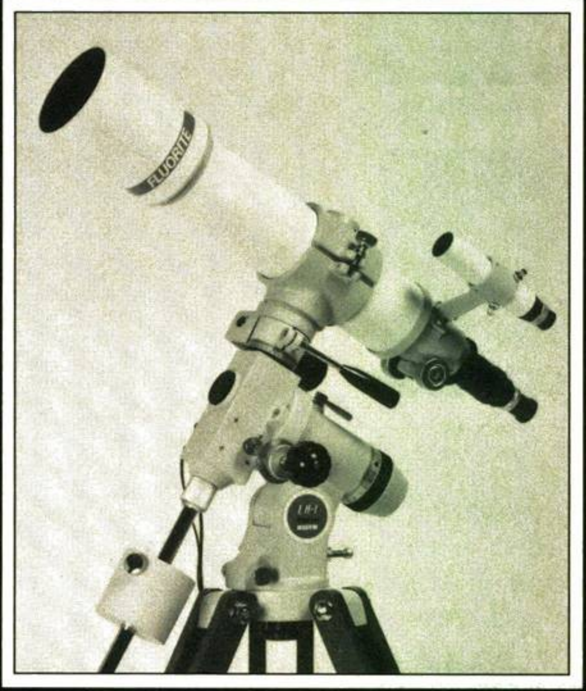

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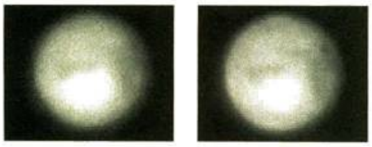

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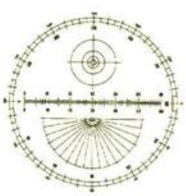

This multi-function guiding eyepiece features a laser-etched reticle **with built-in cordless illuminator** with adjustable brightness control. The eyepiece is a multi-coated 12.5mm Orthoscopic with sufficient eye relief that the reticle can easily be viewed even with eyeglasses.

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## Readings and Resources

**Glorious Universe** (page 30)

*Coming of Age in the Milky Way,* by Timothy Ferris (Morrow, 1988). A delightful history of mankind's growing understanding of the universe in which we live.

*Cosmos,* by Carl Sagan (Random House, 1980). One of the best popular books on astronomy ever written.

**Burst of Gamma Rays** (page 46)

"An Eye on the Violent Universe" by Robert G. Nichols, ASTRONOMY, July 1991. An overview of the Gamma Ray Observatory and what astronomers hope to learn with it.

**Galaxies Gone Wrong** (page 74)

*A Catalogue of Southern Peculiar Galaxies and Associations,* by Halton C. Arp and Barry F. Madore (Cambridge University Press, 1987). An extraordinary collection of data and photographs of galaxies with structural peculiarities, many of which were caused by interaction with neighbors.

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### CREDITS

***Cover:*** Ernest Piini, taken in San Jose del Cabo, Baja California, with a f/6.8 telescope built for eclipse photography, radial gradient filter, Ektar 125 film, 2-second exposure; ***p. 4:*** Richard Horowitz, 28mm f/2.8, Ektachrome 200 film, $^{1}/_{30}$-second exposure; ***p. 14:*** Thomas L. Hunt; ***p. 21, left:*** European Southern Observatory; ***right:*** courtesy Boston University; ***p. 24, top:*** courtesy the European Southern Observatory; ***bottom left:*** courtesy Harvard-Smithsonian Observatory; ***bottom right:*** courtesy National Radio Astronomy Observatory; ***pp. 30-43:*** paintings by Adolf Schaller; ***pp. 44-45:*** NASA photo; ***pp. 46-48:*** illustrations by Phil Kirchmeier; ***pp. 47-49:*** NASA photos; ***p. 49:*** data courtesy Gerald Fishman; ***p. 56:*** Stewart Lollar, 180mm f/2.8 lens, PPC 1600 color negative film, 1-second exposure on June 15, 1991; ***p. 64:*** Evelyn Talcott; ***p. 64-65:*** Andrew Steinbrecher, San Jose del Cabo, Baja California, 700mm lens, Ektachrome 50 film, $^{1}/_{2}$-second exposure; ***p. 65, bottom left:*** Alan Dyer; ***bottom right:*** Eleanor Berry; ***p. 66, top:*** Alan Dyer, Takahashi FC-76 refractor, f/16, Kodachrome 64 film, $^{1}/_{8}$-second exposure; ***bottom:*** Alan Dyer; ***p. 67, top:*** Rich Talcott; ***center, bottom left, and bottom right:*** Alan Dyer; ***p. 68, top, center, and bottom:*** Lynda Eicher; ***pp. 68-69:*** David J. Eicher, 28mm lens, Kodachrome 64 film; ***p. 69, bottom left and right:*** David J. Eicher; ***p. 70, top:*** David J. Eicher; ***center*** Richard Talcott; ***bottom left:*** David J. Eicher; ***bottom right:*** Richard Talcott, Meade 2045, f/10, Kodachrome 64 film; ***p. 72, top:*** courtesy the *Viking Serenade*; ***center:*** Richard Berry; ***bottom:*** Richard Horwitz, 600mm telescope, f/4, Ektachrome 200 film, $^{1}/_{30}$-second exposure; ***p. 73, large photo and inset:*** Richard Berry, $^{1}/_{60}$-second exposure; ***pp. 73a-73b:*** Paul Severance, Cabo San Lucas, Meade 2045 f/10 telescope, Ektar 125 film, $^{1}/_{125}$-second exposure; ***73b:*** Alan Dyer; ***pp. 74-78:*** James R. Foster, 11-inch SCT at f/11, hypersensitized Tech Pan film, data as follows: ***p. 74:*** 210-minute exposure. ***p. 75:*** 200-minute exposure. ***p. 76, top:*** 200-minute exposure. ***p. 76, bottom:*** 196-minute exposure. ***p. 77, top:*** 210-minute exposure. ***p. 77, bottom right:*** 165-minute exposure. ***p. 77, bottom left:*** 180-minute exposure. ***p. 78, top:*** 195-minute exposure; ***p. 78, bottom:*** 210-minute exposure; ***p. 79:*** Chesley Runyon, Jr., 6-inch f/8 reflector at 70x; ***p. 80:*** Jack Newton; ***p. 81, top left:*** Bill Iburg, 14-inch SCT at f/5.5, Ektachrome 400 film, 25-minute exposure with cold camera; ***p. 81, left:*** Dan Marcus and Bill Smith, 12.5-inch f/5 reflector, hypersensitized Tech Pan film, 40-minute exposure; ***p. 81, right:*** Bill Iburg, 11-inch SCT at f/5, Ektachrome 400 film, 25-minute exposure with cold camera; ***p. 91, top:*** Peter Chan, 28mm f/2.8 lens, Fujichrome 400 film, 24-second exposure on June 5, 1991 from Sand Lake, Michigan; ***p. 91, bottom:*** Robert Miller, 24mm f/2.8 lens, Fujichrome Super HG 1600 film, 30-second exposure on June 5, 1991 from Novi, Michigan; ***p. 92, top left:*** Stephen Keene, 31-inch f/7 reflector, photo taken on May 8, 1991; ***p. 92, bottom left:*** Jeffrey L. Jones, 55mm f/2.8 lens, hypersensitized Tech Pan film, 1-second exposure on June 15, 1991; ***p. 92, top right:*** Kim Zussman, 14.5-inch f/8 Cassegrain, hypersensitized Tech Pan film, 100-minute exposure on May 12, 1991; ***p. 92, bottom right:*** Ronald E. Royer, 18-inch f/7 reflector, Tech Pan film, 30-minute exposure on May 16, 1991; ***p. 93, top:*** Kevin Milani, 8mm f/2.8 lens, Ektachrome P800/1600 film (processed at ISO 400), 1-minute exposure on June 10, 1991, from Hibbing, Minnesota; ***p. 93, bottom left:*** Edwin Faughn, 8-inch f/10 SCT at 80x, sketch made on June 8, 1991; ***p. 93, bottom right:*** Don Trombino, 6-inch refractor at f/30, Daystar hydrogen-alpha Energy Rejection filter, Tech Pan film, $^{1}/_{125}$-second exposure on June 10, 1991.

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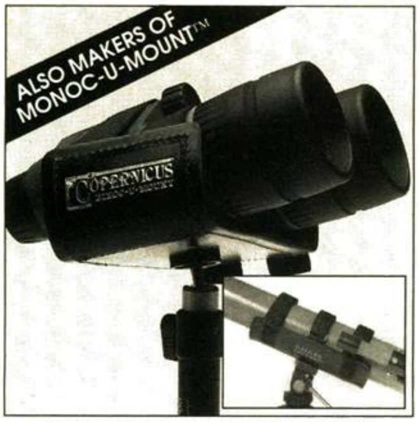

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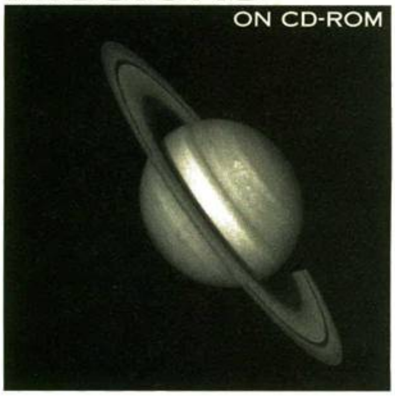

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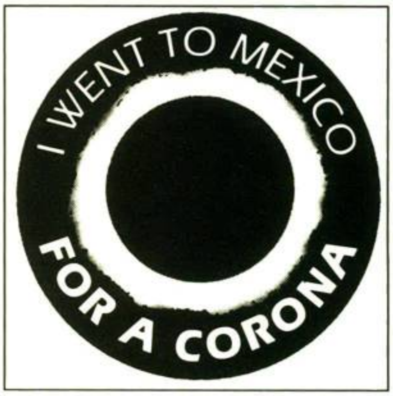

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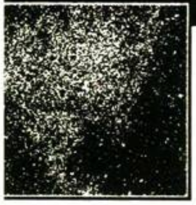

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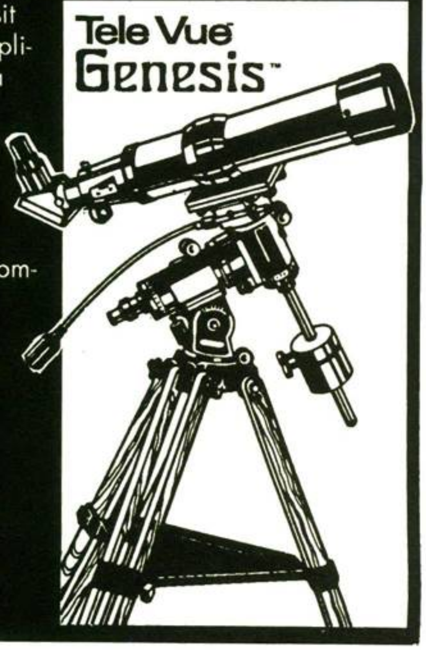

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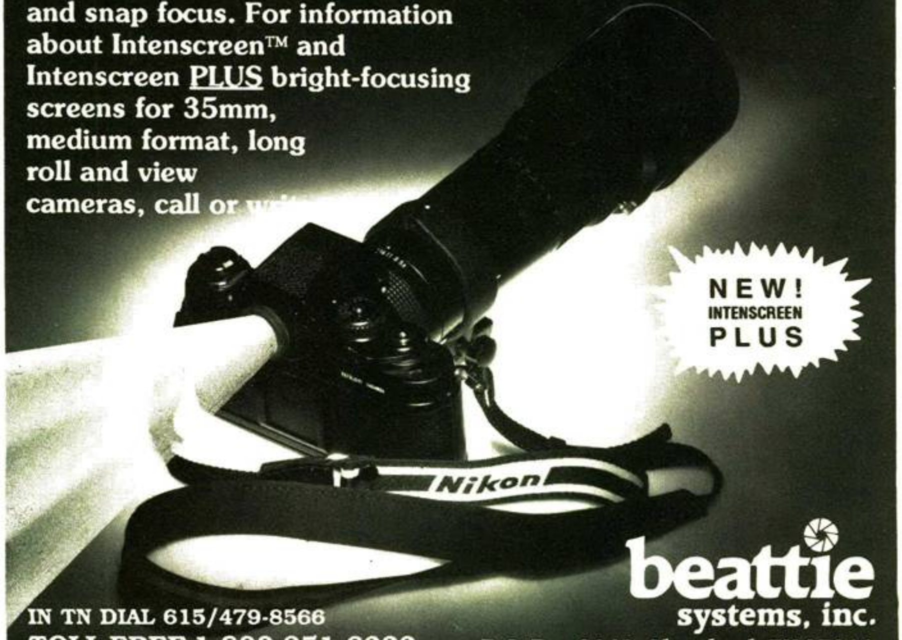

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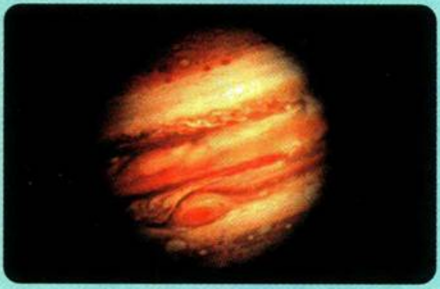

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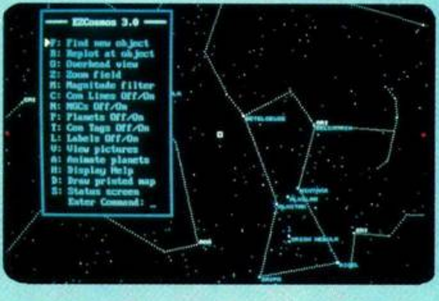
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